Observatory Administration Building
Tonantzintla, Mexico

Vol. I, No. 2 December

Mexican Star Catalogue

Christmas Story

Extragalactic

December

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The Editors Note . . .

IN view of its tremendous circulation, it is unfortunate that in a recent number of the **Ladies' Home Journal**, Mrs. Eleanor Roosevelt answers a question regarding astrology in a manner which is practically an endorsement of so-called "scientific" astrology. Hers was an opportunity to influence millions and to give a direct "yes" or "no" answer.

Especially for those who believe in "sitting on the fence," we quote from a letter of October 15th written by M. Geddes, director of Carter Observatory in New Zealand, to Irma De Bruycker. This expresses what appears to us to be precisely the right plan of action. In this country, the "signs" of which Mr. Geddes speaks have long ago made their appearance, and the time to "adopt vigorous measures" is here.

". . . I can't say that I was particularly surprised to hear that Hollywood was trying to make some money out of the astrology craze . . . as long as there is money to be got from it astrology will continue to flourish. Your remedy seems to me to lie, not in a local fight against one newspaper or one film company, but in the education of your politicians to the point where they will see that the various laws against fortune-telling, etc., are rigidly enforced.

"Fortunately, in this country astrology isn't very much in the public eye. . . . I know of only one newspaper or journal which has an astrological column. . . . Our policy at the moment is not to offer any opposition to it. . . . Should there be signs at any time of its gaining further public support, however, we shall certainly adopt vigorous measures.

". . . If you can organise American astronomers to the point where they will offer united opposition then you will be well on the road to stamping out these superstitious relics."

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DECEMBER, 1941

COVER: The administration building of the observatory at Tonanzintla under construction. The library and lecture room is to the right; the staff offices and workshop are at the left. Photo by Bart J. Bok.

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BACK COVER: Stephan's quintet in Pegasus, N.G.C. 7317-20. A close group of four spiral nebulae and one spheroidal system, exposure 7h 45m, August 26, 27, 1916, with the 60-inch Mt. Wilson reflector. The spiral at left center is really double—two nuclei may be seen. Originally discovered by John Herschel, the group was described in 1877 by M. E. Stephan, of Marseilles, as being "excessively, excessively feeble—excessively small—very difficult to observe."

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Mexico's New National Observatory

By Bart J. Bok
Harvard College Observatory

The Mexican home of Harvard's 3-inch Ross camera (at left). Photo by Sr. D. Taboada.

MEXICO is building a new national observatory! Just a little less than a year ago the then newly elected President Camacho appointed Sr. Luis Enrique Erro as director of a national observatory to be erected somewhere in the vicinity of the city of Puebla, roughly 80 miles east of Mexico City. The actual site of the observatory was chosen a few months later, a hill 10 miles south of Puebla near a small town of Aztec origin called Tonanzintla.

The land for the observatory was given by the state government of Puebla, which helped further by providing the buildings and a road that leads from the Pan-American highway south of Puebla through Tonanzintla to the observatory hill. Governor Gonzalo Bautista of Puebla is proud of the new observatory, and if all goes according to plans, the shrubs and trees that are to be planted should turn the observatory grounds into one of the finest gardens of the State of Puebla.

The observatory is staffed by the Department of Public Education. The staff consists now of Sr. Erro, the director, Dr. Carlos Graef, the assistant director (Ph. D. from Massachusetts Institute of Technology), and Professors Escalante, Urquijo, and Recillas, as regular staff members. Sr. Alva will be in charge of the mechanical shop.

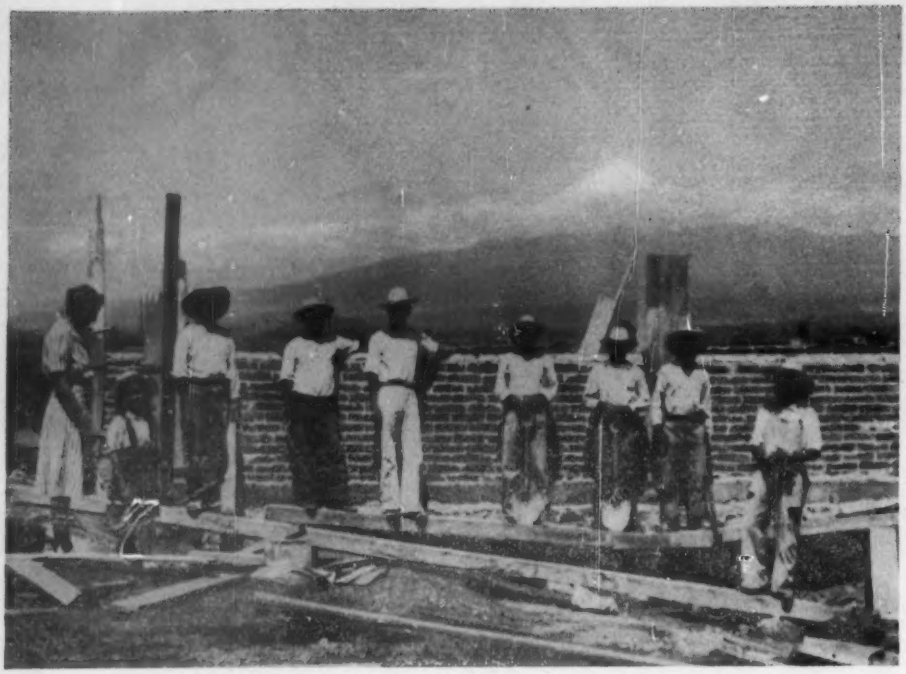
The observatory will be well equipped with instruments bought with funds provided directly by President Camacho. The plans call for two or three cameras of the Ross type, with apertures of 3 to 5 inches, a 12-inch visual reflector, and a 24-30-inch Schmidt camera very similar to Harvard's new Jewett telescope. At this moment, a 3-inch Ross camera, on loan from Harvard College Observatory, is already in operation and Sr. Erro's visual telescope has been mounted and adjusted. The work on the large Schmidt camera, which will be the most powerful telescope in the tropics, is progressing rapidly and it is hoped that the instrument will be installed sometime in January. The plate and mirror are in the hands of the Perkin-Elmer Corp., Glenbrook, Conn., and the mounting is under construction in the shops of Harvard College Observatory.

Group photograph taken on the roof of the home of Sr. Taboada. *From left to right:* Dr. Graef; Sr. Presno, one of Puebla's most enthusiastic amateur astronomers; Sr. Erro; Mrs. Erro; Mrs. Bok; Joyce Bok; Sr. Taboada, Mexico's leading amateur and owner of the only Mexican observatory with a rising floor; and John Bok. The dome of Sr. Taboada's private observatory is visible on the right to the rear. Photo by the author.

The program for the new observatory is being planned partly in cooperation with Harvard College Observatory. Sr. Erro and Prof. Escalante have long been active in the A.A.V.S.O., and the study of southern variables will naturally be part of the program of research. Milky Way research will probably be the second important field of study for the observatory. The telescopic equipment has been planned with special reference to programs of starcounts, colors, magnitudes, and spectra for the southern hemisphere. Other fields of activity have yet to be decided upon, but it seems very likely that photographic studies of meteors and perhaps some phases of solar research will be undertaken in the near future.

The observatory at Tonanzintla is in a very favorable location for the types of research that are being undertaken. It is on a small hill in the valley of Cholula. Cortez Pass, the famous pass through which 400 years ago Cortez led his band of invaders on his almost fantastic trip from Cholula to Mexico City, is almost directly west of the observatory at a distance of approximately 35 miles. It separates the two volcanos, Popocatepetl and Ixtacihuatl, whose snow-capped tops dominate the valley of Cholula. Looking north from the observatory one notices the seven-fold pyramid of Cholula, the "sky line" of Puebla, and the beautiful but grim-looking mountain Malinche, so named after Cortez' Indian mistress. On a clear day—and there are many such days in the state of Puebla—the snow-covered peak of Orizaba, the highest point in Mexico (18, 546 feet), is clearly visible toward the east about 100 miles away. To the south, the partly finished Pan-American highway runs past Atlixco toward Oaxaco and the hot country.

The valley of Cholula is one of the oldest regions of Mexico. It is especially noted for its many churches and cathedrals. Within seven miles of the central square of Cholula (Cholula, Puebla and Tonanzintla form almost an equilateral triangle) there are no less than 366 churches; one for every day of the year



Mrs. Bok and Joyce Bok visit the men at work on the cottage for the visiting astronomer. From the verandah of the cottage one has a magnificent view of the valley of Cholula and the volcano Popocatepetl. Popo is faintly visible in the background. Photo by the author.

plus one extra church for leap years! On Observatory Hill itself one finds many Aztec relics from pre-Cortez days. A 20-minute search of almost any part of the hill is apt to yield several pieces of old Aztec pots, with the characteristic Aztec ornaments still clearly recognizable.

Puebla and the valley of Cholula are on the high Mexican plateau at an altitude of well over 7,000 feet. The latitude of the observatory is +19°, and it is therefore in a strategic position for studies of the southern hemisphere. The climate is delightfully cool and during the winter months (November to May) excellent for observations. During the other half of the year it rains frequently in the afternoon and the clouds are apt to remain during most of the night. But even during the unfavorable season there are generally one or two clear nights a week that are ideal for astronomical observations. In mid-winter, when clouds are almost unknown, the temperature rarely falls below freezing at night. Because of the summer rains, the weather in summer is quite comfortable, not unlike the weather that we enjoy in Boston during early May.

There are plans for a continuous exchange of staff members between Tonanzintla and Harvard. Sr. Erro and Dr. Graef have both spent about a year working at Harvard College Observatory; Prof. Recillas has now been our guest for almost a year. It is planned that members of the staff of Harvard College Observatory spend from time to time four to five weeks at Tonanzintla, where a special visitors' cottage has been built to accommodate visitors from the United States. The pictures that accompany this article show how the four Boks had the good fortune to be the first to be invited, even though the cottage was not yet ready.

The Milky Way program of the Mexican observatory has been planned in connection with the programs of the "star-counting circuit." The Mexicans are planning to look out especially for the starcounts and analyses in the section of the Milky Way in Puppis and Vela and, as far as weather conditions permit, in the regions of intermediate latitudes near the galactic center. A projected study of the regions around the south galactic pole completes the plans for the galactic part of the program. An extension of the Mt. Wilson catalogue of Selected Areas to include the areas at declination −30° is under consideration.

The research program, as it has been proposed for the new observatory, will add more vital data to that already being accumulated in the furthering of astronomical knowledge.

All staff members at Tonanzintla will probably spend one or two days each week in Mexico City where they will lecture at the University of Mexico. The new national observatory will in a way supplement the observatory at Tacubaya where Dr. Gallo has long been the director. The Tacubaya observatory has emphasized mostly time service, fundamental work in stellar positions, and the completion of a zone for the *Astrographic Catalogue*. There will therefore be very little overlapping of the research activities of the two observatories, and the University of Mexico is indeed fortunate to have among its teachers staff members of both observatories. The creation of the new institution will make it possible for the University of Mexico to offer opportunities for graduate work in astronomy.

The formal dedication of the new observatory will probably take place in the second half of February, when a group of scientists from the United States may go down to Mexico City and Tonanzintla to take part in a symposium that is being arranged for the occasion. The Mexican government is already busy making plans for the dedication, which promises to become one of the noteworthy astronomical affairs of 1942. Tonanzintla is planning to show off to best advantage at that time. This summer notices were posted in the town ordering every home owner to paint his house freshly before the dedication. A threat of a 20-peso fine for evaders made it clear that the town fathers are proud of the new observatory!

The observatory is significant in many ways. It represents first of all an important addition to the list of American observatories and with its equipment, latitude, climate, and an energetic staff, it should soon be one of the best-known observatories of the world. In Mexico it stands as the symbol of the new Mexico, the proud Mexico that is taking its place among the strong independent nations of the world. For us in the United States it stands in a way as a symbol of Pan-Americanism, for it is, more than any other observatory, an institution into the creation of which have gone the best efforts of both Mexican and American astronomers.

Looking north along the Pan-American highway toward Puebla and the mountain Malinche. The administration building can be seen as a tiny white speck just beyond the village of Tonanzintla (left part of the photograph). The observatory road runs from the Pan-American highway through Tonanzintla to the observatory. It is about three miles long and was built and paved by the state highway department of Puebla in the record time of six weeks. Photo by the author.

Courtesy, *The Guam Recorder.*

From The Guam Recorder:

Sun-gazers gathered on Tutujan Hill during the equinoctial eclipse inspired Evelyn Griffith Shultz for a study in her vivid series of linoleum engravings. Most informal of any so far reproduced for the "Recorder," this month's cover is in the best candid-camera tradition and sharp-eyed readers will be able with no difficulty to identify sundry prominent members of the Naval Colony. . . .

Enjoyment of the eclipse was made possible for all of us in Guam by the island's one astronomer, Foster Brunton, who published the essential data ahead of time, and together with Lieut. Jack Schwartz, built a special eclipse camera at the site of his outdoor observation post on the brow of Tutujan Hill. Mr. Brunton generously shared his equipment with all comers, and put his special knowledge at our service, so that a fair-sized coterie, who had become interested while the camera was being constructed, arrived to spend the afternoon with him on the twenty-first, and take their own pictures of the sun's image as reflected by the mirror and projected on a white paper held in the focal plane. The image was also reflected in a basin of water, one of the foreground details in the engraving on the cover.

Mr. Brunton is a member of the Royal Astronomical Society of Canada, the American Meteorological Society and the American Association of Variable Star Observers.

"Sun-Gazers on Tutujan Hill"

By Foster D. Brunton

THIS is in reply to your letter of August 5th, regarding the eclipse of the sun on September 21st.

Your letter arrived exactly one week prior to the eclipse. I had known an eclipse would be visible in Guam on that date, but had not been advised that it would be so nearly total in Guam. Your letter was therefore especially appreciated, as I am an amateur astronomer and your information gave me a week in which to prepare for the event. With the aid of an expert photographer, Lt. J. W. Schwartz, of the Civil Engineering Corps of the Navy, I set to work. We spent the entire week experimenting with solar photography, a science entirely new to both of us. Our first attempts were not very encouraging. On Monday, Tuesday, and Wednesday, we attempted to photograph the image of the sun as projected on a white paper background at the focus of a 102-inch focal length mirror of 10½ inches aperture, the longest focal length equipment I have available among my amateur astronomical equipment. We were not pleased with the results of these attempts, as at the time there was a very large, active, and conspicuous group of sunspots visible at the focal plane, but we were unable to record them photographically. However, as these experiments were being made, we learned a few lessons, such as the amount of light necessary for good contrast. Thus, the surface of the parabolic mirror was stopped down to only one square inch, which at 1/100 of a second exposure, with Eastman Panatomic X film, seemed correct. We were thus able, with the aid of a sensitive exposure meter, to gauge the amount of light which we should finally permit to reach the film during the actual attempts to photograph the eclipse.

During the experiments just described, I had been considering the advantages of a focal-plane shutter at the focal plane of our stopped-down mirror. I began work on the building of such a camera on Tuesday, and on Thursday, September 18th, we gave it the first trial. The result was gratifying, as we obtained the image of the sunspots which we had so clearly seen before, but which had eluded all our photographic efforts. We continued these experiments on Friday, the 19th, when we obtained the enclosed photograph of the sunspots.

On Saturday, the day before the eclipse, we set up our homemade equipment on a hill overlooking the city of Agana, and carried out the final experiments. Lt. Schwartz designed a simple but effective light shade which we tried for the first time, with improved results.

Sunday dawned with the sun's weak rays filtering through a dense overhead mat of cumulus clouds, which later turned to nimbus, drenching the island and our hopes of any opportunity to see the

(*Continued on page* 26)

Mr. Brunton succeeded in photographing the eclipse and the sunspots which were associated with the aurora of September 18-19th.

NEWS NOTES

By Dorrit Hoffleit

THE ORBIT OF 61 CYGNI

From the time of Kepler and Galileo, astronomers struggled vainly to discover the distances of the stars. Finally, in 1838, Bessel succeeded in deriving a trustworthy parallax for the star 61 Cygni. In that year Bessel wrote to Sir John Herschel, "I undertook to make this investigation upon the star 61 Cygni, which, by reason of its great proper motion, is perhaps the best of all; which affords the advantage of being a double star. . . ."

The binary character of the star was already recognized by Bradley as early as 1755, and Bessel thought its period was about 400 years. But even as late as the 20th century some astronomers doubted that the two components really formed a binary system. In 1910, Schlesinger and Alden finally proved orbital motion beyond question, but because of the slow relative motion the elements have heretofore been very uncertainly determined.

Now, more than a century since 61 Cygni became the first parallax star, its orbit is at last determined, and in a forthcoming issue of **Sky and Telescope**, Dr. K. Aa. Strand, of Sproul Observatory, will tell about his results obtained by methods described by him in The SKY for May, 1941. Dr. Strand has been ably assisted in his investigation by Miss Virginia Burger, who carried out nearly all the computations.

ASTRONOMERS TO MEET IN DALLAS

Section D (Astronomy) of the American Association for the Advancement of Science will meet in Dallas, Tex., during the next general meeting of the Association there, December 29th to January 3rd. In a circular letter recently, Dr. C. C. Wylie, of the University of Iowa, and secretary of Section D, requested amateur astronomers to make known their interest in the meetings of the Section, and to suggest topics of interest for discussion. It is expected that a large number of amateurs will attend the meetings in Dallas.

ASTRONOMY ABROAD

The third **Bulletin** issued by the Committee for the Continued Distribution of Astronomical Literature gives evidence that some of the astronomers of the belligerent or occupied nations have still been active in their science. The Committee, of which Dr. Bart J. Bok, of Harvard, is chairman, and of which Dr. H. R. Morgan, of the U. S. Naval Observatory, and James Stokley, of General Electric Company, are members, seeks to promote the exchange of astronomical literature between all nations for the duration of the war. Their **Bulletin** gives abstracts of European astronomical papers which might not become otherwise generally available to astronomers in this country.

Bulletin No. 3, issued in October, represents five contributions from France, eight from Italy, and 21 from Germany, the latter including Czechoslovakian, Russian, Austrian, Hungarian, and Danish authorship. Their subject matter covered night sky illumination, latitude variation, zodiacal light, comets, a double asteroid's motion, the solar spectrum, stellar spectra, variable stars, novae, and stellar statistics. It is to be hoped that the authors of these papers and other scientists may continue their work without further interruption, and thereby build a foundation for post-war reconstruction.

SOLAR DENSITIES

In an illuminating article in **Scientific American** for November, 1941, Dr. Henry Norris Russell, of Princeton University Observatory, presents an explanation of modern methods of computing the pressures, densities, and temperatures inside the sun, and concludes with a summary of the final figures obtained by the four investigators, Lowan, Blanch, Marshak, and Bethe.

". . . at a depth of one-sixth of the Sun's radius the temperature is 1,070,000 degrees and the density only 1/220 that of water, or 3½ times that of air under standard conditions. Halfway to the center, the temperature is 5¼ million degrees and the density 92 percent that of water, while 95 percent of the Sun's mass is still inside. Three quarters of the way down the temperature is nearly 13,000,000 degrees and the density 24.6 times that of water. The inner core, in which convective currents occur, has a radius only 12 percent that of the outer surface and contains 12 percent of the Sun's mass. The central temperature is 25,700,000 degrees and the density 110 times that of water, or 78 times the mean for the whole Sun. The corresponding pressure comes out 1,700,000,000 tons per square inch. . . ."

In comparison, Dr. Russell states that the pressure at the earth's center is about 20,000 tons per square inch.

BUHL DEDICATES NEW TELESCOPE

On November 19th, the Buhl Planetarium and Institute of Popular Science in Pittsburgh, director, Arthur L. Draper, dedicated and opened for public use its new 10-inch siderostat refractor, housed in that portion of the Buhl Planetarium building to be known as the Peoples Observatory.

The dedicatory address was given by Dr. Harlow Shapley, director of Harvard College Observatory, and followed by opening of the observatory and unveiling of the telescope. Unlike most other astronomical telescopes, this one is designed for continued public use, so matters of comfort and speed of observation have been placed ahead of the usual considerations in observatory construction. The siderostat, or horizontal telescope, produces a fixed image regardless of the position or motion of the celestial object observed. This image is located indoors, so visitors may observe in comfort in all extremes of weather.

The light of a star, planet or nebula, first strikes the 18-inch Pyrex mirror, which is mounted equatorially in such a way as to reflect the light horizontally into the fixed 10-inch objective lens. The mirror-driving mechanism is controlled from a dial panel at which the observer stands while looking through the telescope. The observatory is divided into two rooms—one kept at the temperature of the outside night air, and the other, in which the visitors observe, at ordinary room temperature.

This telescope is similar to that installed by the late G. W. Cook in his private observatory at Wynnewood, Pa., now operated by the University of Pennsylvania. It is unique, however, in that it "talks"—at the press of a button the Planetarium's sound system brings into the observatory a voice which tells the spectator the story of whatever object he is observing.

The new Buhl instrument was built by the Gaertner Scientific Corporation of Chicago at a cost of $30,000, in a period of more than two years. The objective lens was ground and polished from some of the last optical glass to leave Europe.

AN IMPORTANT ANNIVERSARY

January 8, 1942, marks the 300th anniversary of the death of Galileo.

ASTRONOMY VIA HURRICANE

Special to the Lehigh Valley Astronomical Society

It took a hurricane to bring soldiers of the 32nd Coast Artillery training battalion out to see the stars. It all started after a previous night of havoc and considerable destruction as the result of a 65-mile an hour gale which whipped up the coast of the Gulf of Mexico and gave not only the camp, but all nearby towns a beating . . . rendering all the vicinity in darkness for two nights.

The night following the storm, though, was a beautiful one. The sky was crystal clear, and Camp Wallace, which is usually brilliantly lighted, was blacked out! This gave a thrill to your reporter who hadn't stargazed since he entered the service. The Milky Way was an awe-inspiring sight and in the regions of Sagittarius was particularly brilliant. The moon in a quite "new" phase hung low in the west while Venus stood brilliantly above it. Mars was rising in all its splendor to the east.

Knowing that yours truly was an astronomy enthusiast, it wasn't long before a number of the boys of his own barracks began gathering about him asking this and that. It started in pure fun for fun's sake, but ended in quite an interesting discussion of the possible formation of old Mother Earth. The tidal theory of evolution and the nebular hypothesis were well argued! Someone in the group suggested the formation of a discussion group as a result of the little gathering—thanks to astronomy.

PVT. EUGENE E. CARL
Camp Wallace, Tex.
September 24, 1941.

(From the L.V.A.S. *Bulletin*, October, 1941.)

THE FORGOTTEN PLANETS

By Harry Stubbs

IT is the writer's painful duty to accuse the hitherto respected planets, Mars, Jupiter, and Venus, of the serious crime of stealing the show. The canals and seasonal changes of Mars, Jupiter's belts and swarm of moons, and Venus' brilliance and shyness have combined to attract most of the astronomical interest of the scientific article writers, and hence, of the general public.

There are, of course, occasional exceptions. The rings of Saturn are familiar objects, though I have met people who think rings a necessary attachment to any planet; Mercury's habit of going through life half-baked has received occasional comment; while Pluto, like many of the rest of us, did manage to appear in the newspapers on the occasion of his first appearance in planetary society, but very seldom since.

Two of the large bodies in our solar system, however, have been shamefully neglected by the writers of popular articles. They are Uranus and Neptune.

They have as much right as Earth and Venus to be called "twin sisters," but we live on the earth, and can see Venus without trouble; they are enormously distant from the sun, but Pluto is farther; they are big, but Jupiter and Saturn are bigger; in short, they have the same chance of getting into the public eye as the winning goalie in a one-sided hockey game—he may be good, but has no opportunity to show his talents.

With the telescope, a low-powered eyepiece will show Uranus as a definite disk, in contrast to the point images of the surrounding stars. An increase of power enlarges the disk; but the supply of detail which Mars reveals to such observation is lacking here.

Uranus is of a decided greenish color. Some observers have seen bands across it, similar to those of Jupiter, but much fainter. The eye can see no more, except, perhaps, if the telescope be sufficiently large, the four exceedingly faint satellites. In spite of this, a good deal has been learned about the planet.

We have discovered that we are seeing, not the true surface of Uranus, but the outer layers of an extensive, cloudy atmosphere. We have measured the temperature of these layers, and determined their chemical composition. We know the approximate length of the planet's day, and the peculiar seasons which the unusual inclination of its axis must cause; and all this has been learned in spite of the meager information the cloudy, green disk vouchsafes to the eye. How?

The diameter is obtained quite simply, from the distance and from the angular diameter, which is about equal to that of a penny 1,100 yards away. The probable

	URANUS	NEPTUNE
Diameter (miles)	31,000	33,000
Mass (earth = 1)	15	17
Mean density (water = 1)	1.3	1.6
Surface gravity (earth = 1)	0.90	0.89
Maximum apparent magnitude	5.7	7.6
Radiation from sun (earth = 1)	0.003	0.001
Reflecting power	0.45	0.52
Orbital velocity (miles per second)	4.2	3.4
Eccentricity of orbit	0.047	0.009
Inclination of orbit to ecliptic	0°.8	1°.8

percentage error is fairly large, due to the small angular diameter, but the measures indicate that Uranus has a diameter of about 31,000 miles—four times that of our little earth. Therefore, its volume, or size, is about 65 times the earth's.

Finding the temperature of Uranus is a more ticklish matter. The brightness is no clue; all the visible light that comes from Uranus is reflected sunlight. Its own "heat waves" lie far in the infrared part of the spectrum, and present quite a number of difficulties to accurate measurement. Glass is completely opaque to them; hence, a refracting telescope cannot be used, as the lens would filter out the very rays we want to measure.

Our own atmosphere blocks the infrared rays to a large extent, as well. The loss here cannot be avoided; therefore, it must be determined and allowed for. By repeated measurements of the planet at different altitudes above the horizon, and consequently seen through different thicknesses of atmosphere, this can be accomplished.

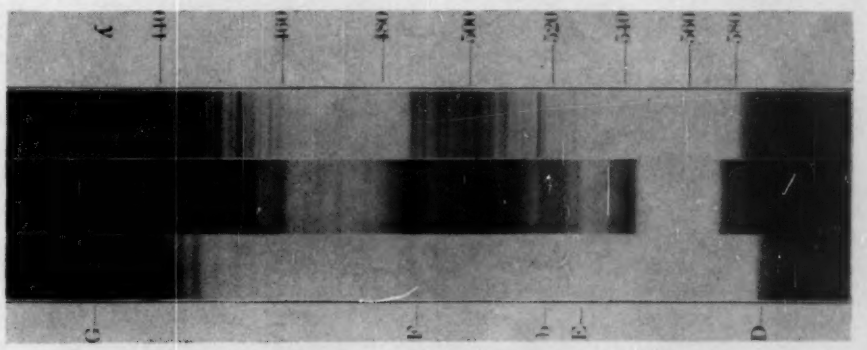
The radiometers used do not, in general, differentiate between the wave lengths received. They simply measure the total radiation falling on them. It is still necessary to sort out the radiations, and to eliminate those which are not due to the planet's own heat—principally, the reflected light waves from the sun. Filters, which transmit certain wave lengths and absorb others, are used for this purpose; each filter must have its absorbing qualities very carefully tested and measured.

With all these items, and a few others, attended to, a series of readings enables the astronomer to calculate how much radiant energy is received from Uranus on each square yard of the earth's surface. It is then fairly easy to calculate the amount radiated from a unit area of Uranus, and from this figure the temperature can be directly obtained. This has been done several times for Uranus, and the results indicate that the temperature of the outer atmosphere layers is about —180° C., or about 280 degrees below zero, Fahrenheit. This does not mean that the surface of the planet is this cold; portions of our own stratosphere maintain a fairly constant temperature of 65 below zero, and the atmosphere of Uranus is far deeper than ours.

The spectroscope, one of astronomy's most versatile instruments, also supplies its share of information. The spectrum of Uranus shows, as, in lesser degree, do those of Jupiter and Saturn, broad absorption bands in the red; bands strong enough to explain the pronounced green color of the planet. For a long time, the substance causing these bands remained unidentified. Recently they were produced in the laboratory by passing light through large depths of ammonia and methane (marsh gas) at high pressures. It was shown that the atmospheres of Jupiter and Saturn must contain extremely large quantities of these gases. Methane is responsible for the bands in Uranus' spectrum; the ammonia is conspicuously absent. This is not surprising, when we recall the temperature of Uranus. It is quite cold enough there to freeze the ammonia out of the atmosphere.

The spectroscope gives another type of information. It permits us to measure the velocity with which an object is moving toward or away from us. If a planet is rotating, one side will be approaching us relative to the center, while the other will be receding. If the rotation is rapid enough, the spectroscope will detect it even when there are no surface features to permit us to determine it visually. Thus Uranus' rotation period, its "day," has been determined as about 10¾ hours.

The direction of the planet's axis was

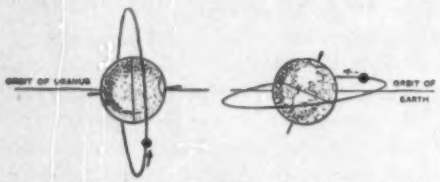


The spectrum of Neptune (middle) shown between comparison spectra of the solar-type star, Pollux, the upper spectrum taken with a narrower slit than used for the planet. The scale is in units of 10 angstroms. Note strong absorption bands at 486, 516, and 543. Lowell Observatory photograph.

determined from the fact that, like most of the other planets, Uranus is not perfectly round, but is flattened slightly at the poles. This flattening can be observed, and shows fairly well the extraordinary inclination of the axis.

Uranus has four satellites; they are faint, but the elements of their orbits are well known. The paths are, as usual, elliptical, and they all lie in the same plane. Their long axes would be precessing slowly, if the gravitational pull of the equatorial bulge of Uranus were forcing this plane into coincidence with that of Uranus' equator. No such effect can be observed, and the conclusion is that the orbits of the moons lie already in the equatorial plane. The orientation of this plane, and hence of Uranus' axis, can be calculated very accurately from observations of the moons, which are too small to affect each other's motions perceptibly.

The results of the calculations are curious. The axis is so inclined that, at midsummer and midwinter, the poles of Uranus point within eight degrees of the sun. The "land of the midnight sun," the frigid zone, reaches to within eight degrees of the planet's equator. Paradoxically, the torrid zone—the belt where, at some time of year, the sun appears directly overhead—overlaps the frigid, reaching nearly to the pole.



Compare the 98-degree inclination of Uranus' axis to the earth's 23½-degree tilt. The orbits of one Uranian satellite and of the moon are shown. (From *Splendour of the Heavens.*)

To an observer stationed at one of the poles, the sun would, on the date of the equinox, appear above the horizon, making one trip around it in a little less than 11 terrestrial hours. Slowly then the sun would rise higher, moving in an imperceptibly narrowing spiral, until at midsummer it would be describing a small circle nearly overhead. Then the process would be reversed, the spiral gradually widening as the sun approached the horizon again. Finally the sun would plunge below, leaving the pole in darkness, to remain so for 42 years, for Uranus requires 84 of our years to complete one of its leisurely passages around the sun. This is the result of its great distance from the sun, 1,783 million miles, or 19.19 astronomical units.

The preceding paragraph is idealized; in reality, if the observer were located on the planet's true surface, he would be unable to see the sun at any time. Several thousand miles of hydrogen and methane, probably helped out by "fogs" of ammonia at the lower levels, must make a rather effective screen. Even the true surface just alluded to is a doubtful reality. Most probably, a layer of gases, liquified by the enormous pressure to which they must be subjected, underlies the true atmosphere.

The solid core must be considerably smaller than the surface we see. If its density were only as great as that of our earth's moon, which is probably a safe lower limit, it could not have a radius as great as 12,000 miles, without exceeding the known value for the planet's mass. This leaves a layer more than 4,000 miles in depth to be filled by atmosphere and "ocean."

The exact conditions which exist beneath the Uranian clouds can scarcely be more than conjectured, for further observational data of some new type is needed before the known laws of physics will enable us to produce, much more accurately than has been done in the foregoing paragraphs, a picture of this planet.

Neptune closely resembles Uranus. It lies farther away, at a distance of 30 astronomical units from the sun, and is correspondingly more difficult to observe. Like its neighbor, its disk is distinctly green in color. The bands across it are even fainter and more elusive to the observer than are those of Uranus.

It possesses a single moon, Triton, whose diameter is estimated at 2,000 miles, so that methods of investigation which proved useful for Uranus are effective also in the case of Neptune.

The planet appears to be slightly larger than Uranus, the accepted diameter being about 33,000 miles. Its day, determined by the spectroscope, lasts 15¾ hours, approximately, and it takes Neptune 165 years to revolve around the sun.

The harmony which exists between the rotation of Uranus and the revolution of its moons is lacking in the case of Neptune. Not only are the equatorial plane of the planet and the orbital plane of the satellite inclined some 20 degrees to each other, but the moon travels in the opposite direction (from east to west). The apparent disk of the planet is too small to detect surely any polar flattening, but there must be some, for the satellite's orbit precesses noticeably. The mathematician dives happily into his calculations, and finally emerges with the information that Neptune's axis is inclined from the perpendicular to its orbit only slightly more than that of the earth. Hence, Neptune lacks the seasonal extremes of Uranus—extremes of solar latitude, that is, since seasonal changes with which we are familiar hardly seem possible in such low temperatures.

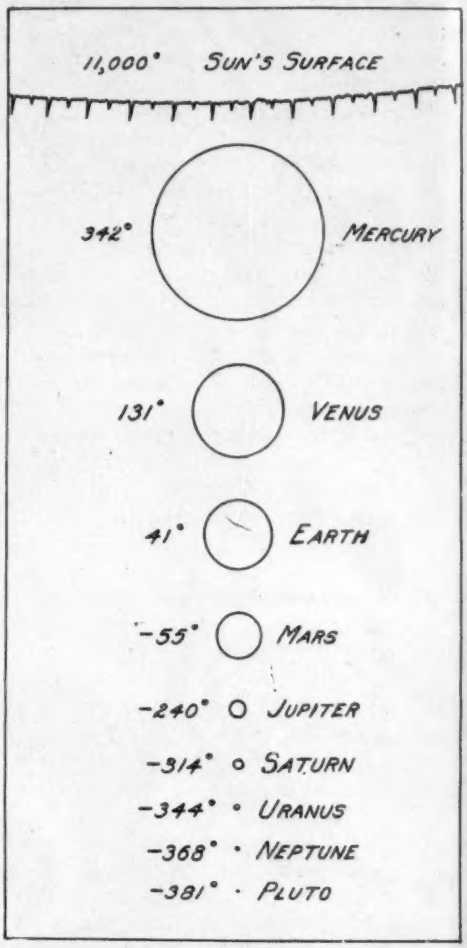
Since Neptune is farther from the sun, its mean temperature is somewhat lower than that of its sister planet. Aside from this, and the few other minor differences already mentioned, a description of one planet fits the other equally well.

In spite of their frozen, inhospitable aspect, these two worlds, circling slowly near the boundaries of our system, give an impression of majesty totally lacking in the still more distant, but tiny and eccentric Pluto, who can't resist dropping in sunward of Neptune each revolution to see what his neighbors are doing. Perhaps this is because Pluto may once have been a second satellite of Neptune.

THE SATELLITES OF URANUS AND NEPTUNE

(from Duncan's *Astronomy*)

Name	*Discovery*	*Distance from primary in miles*	*Period*	*Diameter (?), miles*
Ariel	Lassell, 1851	120,000	2d 12.5h	500
Umbriel	Lassell, 1851	167,000	4d 3.5h	400
Titania	W. Herschel, 1787	273,000	8d 17h	1,000
Oberon	W. Herschel, 1787	365,000	13d 11h	800
Triton	Lassell, 1846	222,000	5d 21h	2,000



The circles indicate the relative apparent size of the sun as seen from the various planets. From Uranus and Neptune, the sun appears very small, and the radiation received warms these planets only slightly. Temperatures are theoretical for a planet without atmosphere (Fahrenheit).

CHRISTMAS STORY

By William H. Barton, Jr.

During the Christmas season, our thoughts turn again to the history of the Christmas festivities, and possible explanations of the Star of Bethlehem. The Hayden Planetarium and the Buhl Planetarium present Christmas shows this month.

Sacramental cults in connection with plants originated in pre-Christian times. Adorning houses with evergreens on New Year's Day was common practice with the Romans. The custom early carried over into the Christian celebration, as the picture of decorating a Roman villa in London, in the fifth century, shows. Courtesy of New York Public Library.

DECEMBER, like the three preceding months, derives its name from the place that it held in the old Roman calendar. The year was divided, nominally, into 10 months, with the insertion of supplementary days to fill out the period required to complete the revolution of the earth around the sun. That is, *December* comes from the same source as the familiar words *decimal, decade,* and *decathlon.*

This month the sun reaches the point farthest south in its apparent annual trip around the sky, so that to us who live north of the equator the month has in it the shortest day in the year. We say the sun is at the *winter* solstice, which this year occurs on December 22nd, about 45 minutes after midnight, Eastern Standard Time. Two thousand years ago, before precession had altered the matter, the sun then was in the constellation of the Sea Goat, Capricornus. And today, the almanac merely notes the signs meaning *sun enters Capricornus,* which, of course, it does not; it is actually in Sagittarius. But with more consideration for our good neighbors in Latin America —where summer is now beginning—the *Ephemeris* does not add, *winter begins.* For if you were on the Tropic of Capricorn, say, in Sao Paulo, Brazil, the sun would stand exactly overhead at noon, and it would be the longest day in the year. Most of our names and definitions were made by observers in the northern hemisphere and predate the good neighbor policy.

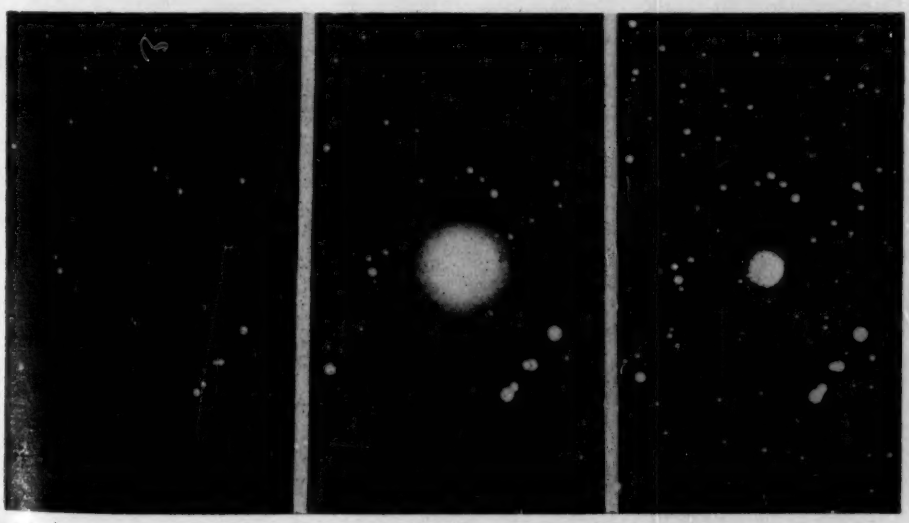
But let it stand that December 22nd is the shortest day and the sun is then lowest in the noon sky. This date falls so close to Christmas that there is no doubt a connection. Sir Isaac Newton, in his *Commentary on the Prophecies of Daniel,* calls attention to the fact that the feast of the Nativity and other important Christian festivals were originally related to the cardinal points of the year.

Christmas was once celebrated on January 6th, still called Old Christmas or Little Christmas in many places. Some used the Jewish Passover season, late in March, and others celebrated as late as September 29th, the Feast of the Tabernacles. There is no doubt that long before the reign of Constantine the date was set for December 25th. The fixing of the date may have been the act of Julius I, who presided as Pope or bishop of Rome from 337 to 352 A.D. St. Chrysostom, a fourth-century church father, tells in one of his epistles how, at the solicitation of St. Cyril of Jerusalem, strict inquiries were made and the date set as we now find it.

Though Christian nations have thus, from an early period in the history of the Church, celebrated Christmas about the time of the winter solstice, or the shortest day, it is well known that many, and indeed, the greater number, of the popular festive observances by which Christmas is characterized, are traceable to a much more ancient origin. Among all the pagan nations of antiquity there seems to have been a universal tendency to worship the sun as the giver of life and light, and the visible manifestation of the highest deity. Various as were the names bestowed by different peoples on this object of their worship, it was still the same divinity. Thus, at Rome, it appears to have been worshipped under one of the characters attributed to Saturn, the father of the gods. Among the Scandinavian nations, it was known as Odin or Woden, the father of Thor, who seems afterwards to have shared with his parent the adoration bestowed on the latter, as the divinity of which the sun was the visible manifestation. With the ancient Persians the name of the god of light was Mithras, apparently the same as the Irish Mithr, and with the Phoenicians it was Baal or Bel.

Concurring thus as regards the object of worship, there was a no less remarkable uniformity in the period of the year at which these different nations celebrated a grand festival in its honor. The time chosen appears to have been universally the season of the winter solstice, from which the new year was frequently reckoned. This unanimity is to be ascribed to the general feeling of joy which all of us experience when the shortening of the day reaches its limit and the sun recommences its upward course and announces that spring and summer are approaching.

By the Romans, this anniversary was



Photograph of Nova Pictoris, 1925. At the left, it is the faint star in the center of the field. At the right it is already fading. Nova Pictoris reached 1st magnitude at maximum, and was then a conspicuous naked-eye object.

celebrated under the title of Saturnalia, or the festival of Saturn. Everyone feasted and rejoiced, work and business were for the season entirely suspended, the houses were decked with laurels and evergreens, presents were made by parents and friends, and all sorts of games and amusements were indulged in by the citizens. In the bleak north, the same rejoicings took place, but in a ruder and more barbarous form. Fires were extensively kindled, both in- and out-of-doors, blocks of wood blazed in honor of Odin and Thor, and the sacred mistletoe was gathered by the Druids.

In the early ages of Christianity, its ministers frequently experienced the utmost difficulty in inducing their converts to refrain from indulging in the popular amusements which were so largely participated in by their pagan countrymen. But at last, convinced partly of the inefficacy of their denunciations, and hoping to further the spread of Christianity, the Church endeavored to amalgamate, as it were, the old and new religions. Ingrafted thus upon the Roman Saturnalia, the Christmas festivities in Britain were superimposed first on the Druid rites and superstitions, and then, after the arrival of the Saxons, on their ancient customs and ceremonies. And thus came Christmas.

Inseparably connected with Christmas is the story of the Magi who followed the star to Bethlehem. And inseparable from that story is the question, "What was the star?" The easiest answer, of course, is that there was no such star, and even if there had been, astronomy now is in no position to tell what it was. But there is the story, and why is it not as legitimate a subject for speculation as the origin of the solar system, or what makes a nova? It is true that we do not *know* what it was, or even *that* it was. But what could it have been? The description is meager and no doubt inaccurate. Those who recorded it were not astronomers, so we must not quibble over every word and syllable. About all we know is "the star which they (the Magi) saw in the east, went before them, till it came and stood over where. . . ."

Even today we use the word *star* for many objects that are not stars in the strict sense of the word. An evening star is a planet; a shooting star is a meteor. The old astronomers called comets bearded stars, and the moon was once classed as a planet or wandering star. The hint about the star's motion tells us nothing. A meteor could very readily go "before them," or a comet would over some weeks show considerable motion among the stars. A planet even, especially Venus, could quickly change its place in the heavens. All these might appear to stand still, except for the daily rising and setting.

So the Christmas star might have been any one of many things or perhaps a combination of several. There must have been quite an interval between the time the Magi saw it in the east and their arrival in Bethlehem. East probably does not mean the eastern "sky" but the eastern "country." If this is the interpretation, the star must have first appeared to them in the western sky.

Meteors are of such frequent occurrence that only one of unusual brilliance could have been interpreted as a sign in the sky. The irregularity and suddenness of their appearance have always given meteors a supernatural rating. Only in modern days have meteors been brought within the sphere of astronomical law. When an exceptionally bright fireball is seen, it might easily appear to call attention to some particular direction or place. Today inexperienced observers imagine that such a particle "falls" only just beyond their horizon, when it may be hundreds of miles away. The biblical story is not an accurate account and was probably never intended to be.

A comet is in much the same class as a meteor. Up until Halley's time comets were things apart. Planets might obey orderly laws but a comet could scarcely be expected to do so. Comets were signs in the sky, portents of events to come. And such they must have been for the Wise Men, who were stargazers, but not Newtonian astronomers. To them a comet came unannounced and went no man knew whither. But, you may ask, since certain comets are now known to be repeaters, can we not check back and see whether there was one then? Yes, if you can tell us when "then" was. The date of the Nativity is not known. Students set it over a period of 10 to 12 years, and in that time there may have appeared not one but several comets. Even Halley's, that most famous of all comets, appeared within the stated period.

A *nova* or temporary star is about as mysterious. It, too, comes unannounced and fades leaving not a trace or clue to the naked-eye observer. A nova appeared in 1572 and is generally known as Tycho's star, because the famous Tycho Brahe studied it diligently. It became so bright that it could be seen in full daylight. But when it faded it could not be found, and to this day cannot positively be identified. Tycho—as he thought—described its position. But since his day the telescope has brought into view many times as many stars as Tycho ever knew. How little chance there is, then, to know if the Wise Men saw a *supernova*, as these most brilliant outbursts are called. And perhaps a nova that we might see now and definitely describe will be as hard to identify in the years to come. Over the years standards and methods and nomenclature suffer change—and the past is hard to know and uncertain to identify.

There have been many such stellar outbursts, though perhaps none in historic times as noteworthy as Tycho's. There are

The custom of slaughtering animals was originally in celebration of the winter solstice. Later, it became part of Christmas festivities. Saxons leading oxen to slaughter, fifth century A.D. Courtesy, New York Public Library.

records of novae in 952 and 1265, but the accounts are so vague that they may easily have been comets, not novae. The guess was hazarded that these might have been earlier repetitions of the star Tycho saw—that every 315 years or so an outburst might be expected—that it was a periodic occurrence of the Star of Bethlehem and would appear again toward the end of the 19th century to announce the second coming of Christ. But no confirmation of this idea has been found, and no such nova has reappeared.

The planets have come in for their share of interest in connection with the story. The Magi were no doubt keen students of the sky, watching for unusual occurrences. They were astrologers, attempting to foretell events by the planets and stars. This has been an argument both for and against the planetary configuration theory. On the one side we can say that they would likely interpret any strange or unusual combination and by their constant watching would not miss such an event. On the other hand, because of their consistent study, the motions of the planets would not startle the

Wise Men as would the appearance of a comet or a nova.

Be that is it may, there were in the period during which the Nativity might have occurred several remarkable planetary events. In the spring of 7 B.C., a conjunction of Jupiter and Saturn took place in the constellation of Pisces, the Fishes. Kepler, who saw a similar arrangement in his own 17th-century sky, suggested the idea. His critics say, however, that the planets were more than two moon diameters apart and therefore could not have appeared as a single "star." Moreover, a similar event had happened 59 years earlier and that should also have aroused the interest of the Magi.

Then in 6 B.C. another planet joined the Jupiter-Saturn pair to form a triple figure that was most striking and so unusual that the Magi's records probably did not include its previous appearance. This too was in Pisces, a constellation that some of the early interpreters had held was of special significance to the Hebrews.

Even the planet Venus is a possible explanation for the star. Perhaps its shining as evening star might have been a "sign in the heavens." Yes, for even today, with all our teaching and planetarium lecturing, some people wonder what Venus is—especially when they see it sometimes in the evening, sometimes in the morning.

Of course, one really comes to no conclusion. There is a continual procession of stellar events and it is not difficult to take one out and give it special significance. Maybe it was, as many believe, not a "star" that comes within the pale of astronomy but something subjective—a vision to those who would be metaphysical—an illusion to those who must somehow account for it.

From where we stand nearly 2,000 years beyond, it is impossible to say.

LATITUDE-TIME DEVICE

A new astronomical invention of earthly significance, designed to help the problem of navigation in high-flying airplanes, has been invented by Dr. N. Wyman Storer, of the University of Kansas. By a system of mirrors, he brings two stars, such as Polaris and Vega, into the same field of view of his sighting telescope, and when this is done the telescope is automatically pointing at the north celestial pole. From dials on the instrument, the sidereal time and latitude may then be read directly. Leveling is done by a bubble or similar horizon device.

Dr. Storer exhibited a preliminary model of his new invention before the American Astronomical Society in September. He said the rapidity with which the position may be read after taking the sight, and the necessity for making only one observation, would more than offset any difficulty in sighting the two stars at one time, especially in the smooth air of of the substratosphere.

Venus as the Christmas Star

By Jesse A. Fitzpatrick

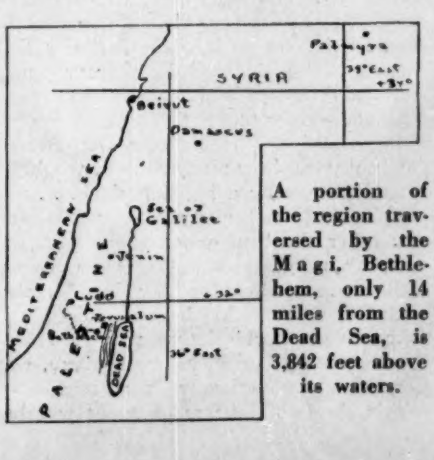
DURING the coming Christmas holidays the planet Venus will reach its phase of greatest brilliancy for the current year, and will appear as an evening star in the southwest. Due to its location on the southern side of the ecliptic, in the constellation Capricornus, it will not appear to us as conspicuous as it will to those who live in the tropics or southern hemisphere. This bright phase occurs approximately every 19 months; the last was at the end of May, 1940.

Immediately following this phase, the planet approaches the sun rapidly, passes by it, rises as a morning star, and at the end of 2½ months again appears at its maximum brilliancy. This morning occurrence is also repeated at intervals of about 19 months.

In the year 1938, the evening phenomenon happened on October 15th, and the subsequent morning phase of greatest brilliancy occurred on the day after Christmas. If the time intervals of 19 months were exactly spaced, 1,224 of them would show this morning phase to occur at Christmas time in the year 1 B. C., and two more would bring the event to the latter part of October in 4 B. C., the year generally accepted as that in which Christ was born. The periods are not exactly 19 months—some are longer, some shorter; but it is safe to assume that at some time during the latter part of the year 4 B.C., the phase of greatest brilliancy was reached.

We learn from Roman records of the death of Herod the Great in 4 B.C., so the Nativity must have occurred in that year or earlier. Josephus tells us of a census taken in that year, and it was this census that caused Mary and Joseph to go from their home in Galilee to be enrolled in Bethlehem of Judea, the country of their forefathers. We have no means of knowing the actual month of the year in which the birth of Christ took place. The period of rejoicing which we call the Christmas season is an old pagan custom and followed soon after the winter solstice.

When Venus reaches its period of maximum brilliancy, it is of interest to both astronomer and layman. Unfortunately, in our mid-northern latitudes we seldom see it high enough above the horizon to appreciate its real beauty. Occasionally in our summer months, as in August, 1940, it is on the high side of the ecliptic and in perfect position for observation, but our long dawn then detracts from its brightness. In a sub-tropical latitude, such as that of Bethlehem, this is not the case, and the planet is high enough in the sky to be seen in all of its glory. At such times it casts a wake of light on the water as does the moon, and it is a rare treat to see these two celestial bodies in the same part of the sky casting parallel wakes over the ocean.



A portion of the region traversed by the Magi. Bethlehem, only 14 miles from the Dead Sea, is 3,842 feet above its waters.

We often marvel at the brilliancy of the star Sirius, commonly known as the Dog Star, as it shines in the south on cold winter evenings. Venus in its brightest phase is more than 15 times as bright as Sirius, the light from it being powerful enough to cast conspicuous shadows.

It is customary for the editors of the December issues of astronomical magazines to publish the opinions of astronomers as to what the Star of Bethlehem might have been. Two conjectures have predominated in these articles: the first, that it was a supernova; the second, a close conjunction of the planets Mars, Jupiter, and Saturn—so close together as to appear as one star. This is not quite possible due to the inclinations of their orbits, but, if it were, their combined brilliancy would be less than one half that of Venus at its brightest phase.

To my mind, Venus is the answer to this very old question, because of its extreme brilliancy, the frequent recurrence of its bright phases, and its perfect location in the sky at these periods, to guide the Magi to their destination.

In the second chapter of the **Gospel** according to St. Matthew, we read, "Now when Jesus was born in Bethlehem of Judea, in the days of Herod the king, behold, there came wise men from the east to Jerusalem, Saying, where is he that is born King of the Jews? for we have seen his star in the east, and are come to worship him." Tradition tells us these Wise Men, or Magi, came from Persia, which is more than 1,000 miles east of Palestine. When traveling to Jerusalem or Bethlehem, they would go toward the west, so the question has often been asked, "How did a star in the east guide them, when their general direction was westward?" The answer is simple if one is acquainted with the geography of the Holy Land, and knows the location of the old Midian highway over which they must have traveled.

This Midian highway, starting in Persia, crossed the Syrian desert through Palmyra and Damascus, and thence turned southward by the eastern shore of Lake Galilee, crossed the Jordan River and traversed the Esdrelon Plain to (what is now) the town of Jenin, near the ancient Megiddo. This was the gateway to the hills of Samaria, and a road due south would bring the traveler to Jerusalem. These hills, however, were very steep, and the Midian route avoided

(*Continued on page 25*)

Dr. Harlow Shapley

HARLOW SHAPLEY HONORED

THE members of Harvard College Observatory staff tendered a dinner to their director, Dr. Harlow Shapley, on Saturday, November 8th, in celebration of his first 20 years as their leader. Besides the staff and students, the Visiting Committee in astronomy of Harvard University and a few special friends were present.

Leon Campbell, Pickering Memorial astronomer, and dean of the staff, was master of ceremonies. Only he and three others are yet at the observatory of those who greeted Dr. Shapley when he came to Harvard from Mt. Wilson two decades ago. Since then the observatory and its work have grown in many ways—not only more people, more buildings, more out-of-town stations—but far more research projects, a graduate department, more cooperation with other departments of the university. Among Dr. Shapley's university activities in general, outstanding is his sponsorship of the organization of scientific societies at Harvard, such as Sigma Xi and Gamma Alpha.

Dr. Richard Prager, formerly of Berlin, spoke with feeling in behalf of the European scientists (not only astronomers) whom Dr. Shapley has helped find homes and places to work on this side of the Atlantic, when driven from their homes abroad.

Prof. Henry Norris Russell, director of Princeton University Observatory, recalled Dr. Shapley's student days at Princeton, when modern methods of studying eclipsing variables were just beginning; he told how the young Missourian's limitless energy showed itself even then, in his computation in less than two years of the orbits of 90 eclipsing systems.

Among other speakers of the evening were President James B. Conant of Harvard University, President Emeritus A. Lawrence Lowell, George Agassiz, and Prof. James R. Jewett. Dr. Bart J. Bok spoke on behalf of the Department of Astronomy, while other speakers were Miss Henrietta H. Swope, Leland Cunningham, and Mrs. Cecilia Payne-Gaposchkin. Hers was the principal address of the evening, and included a resume of changes in astronomical thought and activity during the past 20 years, followed by some considerations of future progress. In part, Mrs. Gaposchkin said:

"Twenty years ago when the new director entered upon his duties, what were his surroundings? I don't mean the Harvard College Observatory of 20 years ago (though the reconstruction would be an eye-opener to some of you); I am thinking about the universe. What sort of universe came with the observatory? How does it compare with ours of today?

"Frankly, the universe of 20 years ago bears rather less resemblance to the cosmos of today than the world maps of Ptolemy bear to the atlas of the **Encyclopaedia Britannica.** One would hardly know it for the same universe. Indeed, it **wasn't** the same universe.

"Listen to this: 'Direct evidence is entirely lacking whether the spiral nebulae are within or without our stellar system. The mere fact that the spiral nebulae shun the galaxy may indicate that they are influenced by it.' And this: 'If spiral nebulae are within the stellar system, we have no notion what their structure may be. . . . If however they are external to the stellar system we have at least a hypothesis that can be followed up. . . . If each spiral nebula is a stellar system, it follows that our own system is a spiral nebula.'

"No, that was **not** written a hundred years ago by Sir John Herschel. It is a quotation from Eddington—from the book that I bought to use as a text only 19 years ago—the book that was the standard work on the structure of the stellar system.

"Here is another quotation from the same book: 'The distance of the Lesser Magellanic Cloud is found to be 10,000 parsecs—the greatest distance that we have yet had occasion to mention.' Or this: 'The whole number of nebulae bright enough to be photographed has been estimated . . . at 160,000.'

"Twenty years ago the explorers of the universe had a picture like that. Look at it today! So far as size is concerned we think in numbers of quite a different order. Instead of 10 kiloparsecs, 'the greatest distance that we have yet had occasion to mention,' 100 million parsecs is a commonplace nowadays. And if there are but 160,000 nebulae bright enough to be recorded, the Harvard observers have succeeded in photographing the unphotographiable and in measuring the unmeasurable, for if you go into the Nebular Department and do a little eavesdropping you will hear of 400,000 galaxies already surveyed—more only awaiting the eyepiece; and even the Nebular Department dare not guess how many nebulae would be brought down by a big Schmidt. . . .

"There are not many of you who can remember the time when there were, so to speak, no galaxies. I remember it very well. I remember the day Dr. Shapley said: 'My universe has been shattered.' . . . Our modern world-picture, with its galaxies, its supergalaxies, its metagalaxy, was perceived — consciously perceived — all within the last 16 years. I doubt whether any other observational science can point to a parallel expansion.

"If our view of the external universe has changed, our own galaxy has undergone a transformation too. Go to the Milky Way Variable Department and you hear of groping among the clouds at the galactic center—of distances greater than 10 kiloparsecs, the extreme of 20 years ago—of variable stars glimpsed beyond the center itself. The very galactic center has become a commonplace. Even we oldsters who saw the thing done are apt to forget how striking is the confirmation by other means of the galactic center deduced from the globular clusters over 20 years ago. The variable stars, the novae, the galactic rotation—one of the great astronomical advances of our two decades—all conspire to anchor the galactic center in its place.

"If the galaxy has grown bigger (with a fluctuation or two) it has also grown fatter. Go to the High-Latitude Variable Department and hear of the system of cluster-type variables as far out as 16 kiloparsecs. But the Milky Way is not alone. The Department of Galactic Photometry will tell you that other galaxies suffer from **embonpoint.**

"Twenty years ago there was no such subject as interstellar absorption—or if there was it went under another name. 'The fact that the nebulae shun the galaxy,' for instance. But today, see the Nebular Department crowding round the galactic windows. Ask the Bureau of Galactic Research why the Carina region is their chosen battlefield. Ask the Photometric Department what is the matter with the north pole, or the Variable Star Department, 'Why the scatter of the period-luminosity curve?' 'Absorption,' is the answer, every time.

"I think that the changes of cosmic landscape have been greatest and most striking in the realm of the very large. Our old friends, the stars, have not altered so much. There are new faces among them, white dwarfs, and such. The sun, with his new-fangled hot corona, has perhaps given us the greatest shock of all. But we have not plucked the very heart out of their mystery. Not yet. Of some of their inmost secrets we seem to hear a whisper. But that belongs to the future. . . ."

After Mrs. Gaposchkin's address, Mr. Campbell called upon Miss Arville D. Walker, Dr. Shapley's secretary, who presented him with a scroll signed by all those present. In accepting the scroll, Dr. Shapley said he hoped none of those present would ever find themselves in his embarrassing position! He then expressed his appreciation to all those who had helped him in his work, with special thanks to the two men, Mr. Agassiz, and his teacher, Dr. Russell, who have never failed him when counsel was needed.

DORRIT HOFFLEIT

AMERICAN ASTRONOMICAL SOCIETY

The 67th meeting of the American Astronomical Society will be held in Cleveland, Ohio, at the Warner and Swasey Observatory, Case School of Applied Science, Dr. J. J. Nassau, director, on Monday and Tuesday, December 29th and 30th.

ASTRONOMICAL ANECDOTES

A "SCURRILOUS POSTER"

DECEMBER is perhaps not the best month to use in setting forth the way in which astronomers sometimes come very much down to earth, but the finding of a true copy of a handbill for which I have been on the lookout for some time has decided me in the matter. Here is the handbill, which was posted very widely in the neighborhood of London, in 1836:

OBSERVATORY
CAMPDEN HILL, KENSINGTON

To Shy-cock Toy Makers—Smoke Jack Makers—Mock Coin Makers—Dealers in Old Metals—Collectors of—and Dealers in Artificial Curiosities—and to such Fellows of The Royal Astronomical Society,

as at the meeting of that most learned and equally upright body, on the 13th of May last, were enlightened by Mr. Airy's (the Astronomer Royal's) profound expose of the Mechanical Incapacity of English Astronomical Instrument Makers of the present day.

TO BE SOLD

By hand, on the premises, by Mr. Macleland, on Wednesday next, December 21st, Between 11 and 12 in the forenoon, Several hundred-weight of Brass, Gun Metal, &c, &c, Being the Metal of the

GREAT EQUATORIAL INSTRUMENT

Made for the Kensington Observatory by Messrs.

Troughton and Simms,

The Wooden Polar Axis of which, by the same Artists, and its Botchings cobbled up by their Assistants,

Mr. Airy and the Rev. R. Sheepshanks,

were, in consequence of public advertisement, on the 8th of July 1836, purchased by divers Vendors of Old Clothes and Licensed Dealers in Dead Cows and Horses, &c, &c, with the exception of a fragment of Mahogany, specially reserved at the request of several distinguished Philosophers, which, on account of the great anxiety expressed by Foreign Astronomers and Foreign Astronomical Instrument Makers, to possess, when converted into Snuff boxes, as a souvenir piquant of the state of the Art of Astronomical Instrument Making in England during the 19th Century, will, at the Conclusion of the Sale, be disposed of, at —— per pound.

In this department of The SKY, in April, 1940, we find these lines: "An object glass 12 inches in diameter was made by Cauchoix, of Paris. For some reason, the French astronomers of that time seem to have ignored Cauchoix and his ability, but . . . Sir James South purchased the lens and had it mounted by Troughton, the conceited but distinguished British optician. The mounting was very poor, however, and was the cause of a long lawsuit between Sir James South and Troughton."

The word "conceited" can now be changed to "overconfident," for Troughton, spurning the conventional type of mounting made so popular by Fraunhofer and (later, in America) Henry Fitz, leaped a century ahead, and used the yoke-type polar axis, as in the Hooker reflector at Mt. Wilson. The complaint made by Sir James was flatly that the telescope was no good for work with double stars, that there was a vibration set up in setting the instrument, because the polar axis was too flimsy. Sheepshanks, called in later as an arbitrator, confessed that it was a "most unpleasant discovery" to find there had been no provision made against twist of the polar axis framework. This was corrected, by putting in braces, and covering the whole thing with wood, until Mr. Donkin, who supplied the workmen, said "it felt like a tree." Double-star observations made thereafter by Sheepshanks, Simms, and Airy, were perfectly satisfactory.

A small volume which belongs to a friend of mine contains the correspondence between Sir James South, Troughton, and Simms, and various other persons who eventually got dragged into the fray. Sir James was vicious and stupidly set in his demands, threatening lawsuit unless the "contract" were lived up to. Simms replied that when the "contract" was produced, there would be time enough for such talk, and that so far as he knew there was no such document specifying any degrees of tolerance.

It was 1829 when South bought the Cauchoix lens; in 1833 the suit began, and the arbitration occupied most of the years 1833-34. But after the alterations described above, Sir James turned Sheepshanks and the other experts out of his observatory, from November, 1833, to July, 1834, and then only by court order were they readmitted for a month, to try the instrument. They did so, with the final result that the whole thing, the original mounting and all the subsequent costs and alterations, amounting to about $40,000, had to be paid for by South. He was madly bitter against those who had been even neutral in the litigation, and the handbill (and other similar paid advertisements in newspapers and journals) was the result.

The story really began much earlier, when the charter for the Royal Astronomical Society was applied for. South was president, and as it was expected that the charter would be granted immediately, it was stipulated in the charter that he should be the first president. But South took so long about getting the charter to the attention of the proper authorities that his term expired, and Brinckley succeeded him. South started to make trouble, but at last stayed away from the meeting of April 8, 1831, when the charter was agreed to. There was a later episode, when South was ruled out of order and strongly censured for making a motion (February 14, 1834) that the council of the R.A.S. be recommended to give a gold medal to Stratford, for compiling the *Nautical Almanac* (a back-handed slap by South, against those who had previously received medals for what he thought was routine work). This series of incidents culminated in the "scurrilous poster," as it is called in the *History of the R.A.S.*, published in 1923.

Perhaps Sir James South was correct in believing that the type of mounting called the German equatorial would be the best, but the time to insist upon it was before, not after, the actual construction. Certainly his later behavior, as revealed by this "Most Confidential" (in South's manuscript) small volume, deprives him of any sympathy we might feel toward him.

R.K.M.

LADD OBSERVATORY FIFTY YEARS OLD

On October 21st, Brown University celebrated the 50th anniversary of the opening of its Ladd Observatory. Director Charles H. Smiley and Mrs. Smiley conducted an observatory open house, and Prof. Frederick Slocum, Brown '95, and director of Van Vleck Observatory, spoke on international cooperation in astronomy. Ladd Observatory was erected in 1891 through the generosity of former Governor H. W. Ladd of Rhode Island.

PROGRESS IN EXTRAGALACTIC

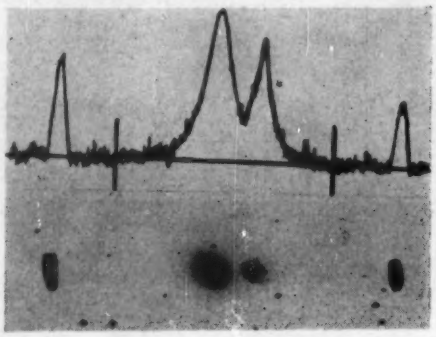
By Katherine Gordon, *Lick Observatory*

ASTRONOMERS as a whole are not given to tree-climbing, but give them some galaxies to play with and they often get out on a limb. Present observational data are just sufficient to make this sport fun, and the right answers are a good safe decade away. The investigations fall into three subdivisions: observation, determination of absolute characteristics from the observations, and theoretical work, which here amounts to scientific guessing. The first subdivision includes work on the apparent number, magnitudes, sizes, shapes, colors, position, and radial velocities of galaxies. The second includes the space distribution, absolute magnitudes, real sizes, and masses. The theories then try to relate and account for all these, the problems ranging from difficult to completely baffling.

The task of counting galaxies down to certain limits of magnitude is being carried on at Harvard under the direction of Dr. Harlow Shapley. The work is more than half finished and already over half a million galaxies are counted. On completion, we shall have a good idea of the apparent distribution of galaxies over the whole sky. In the areas already surveyed, instead of wheels within wheels, we find clusters behind clusters; such is the complexity of our universe. Each area seems to have too many or too few systems compared to neighboring areas. The clustering tendency appears to be the rule rather than the exception.

Among these galaxies we should like to know the relative frequency of different types. The Shapley-Ames catalogue of galaxies down to the 13th magnitude gives quite complete data for this purpose. On the whole, spiral galaxies are more frequent than the elliptical forms. However, the relative frequency of elliptical galaxies seems to increase within clusters. Studies, made at Mt. Wilson, of nearby clusters seem to indicate that the more compact the cluster, the higher the frequency of elliptical forms. Elliptical galaxies are classified according to the degree of apparent flattening. This includes the effect of orientation in space. The lenticular ones would appear round if they were tilted 90 degrees, while the appearance of the truly spheroidal ones would not change. The spheroidal galaxies are apparently considerably more numerous than the lenticular type; but if we assume that all galaxies are oriented at random, and apply corrections for this effect, the lenticular form actually is slightly more prevalent.

For detailed knowledge of the structure of different types, we must study individual bright galaxies. We no longer trust our eyes to examine a photographic plate, but make use of an instrument called a *microdensitometer*, which is far more sensitive. It records the degree of blackening at points on the photographic plate, corresponding to a measure of the amount of light coming to us from different parts of a galaxy. The value of the instrument is well illustrated by the recent work by Williams and Hiltner at the University of Michigan. They traced the major axis of the Andromeda nebula out to 400 minutes of arc, while the visual extent is only 160 minutes.



Microdensitometer tracings of the nebula M61 and its companion. Two vertical marks on the tracing show the extent of the nebula. The outermost spots are ink marks.

The microdensitometer is also used to compare the image of a galaxy on a red-sensitive plate with an image on a plate sensitive to blue light. The color of the central region of a galaxy shows a dependence on type. The elliptical forms are redder than the spirals. One explanation may be that the open spirals contain blue giant stars while it seems certain that elliptical ones do not. The color of material within a spiral galaxy has also been found to vary. The arms are bluer than the central mass, and knots of bright matter occurring along the arms are bluer yet.

Supernovae continue to be found on plates taken at the Oak Ridge station of the Harvard Observatory and with the 18-inch Schmidt telescope on Mt. Palomar. Recent discoveries have enabled the Mt. Wilson observers to distinguish between two separate types of supernovae. Those which were first recognized as a separate class were all of the very bright kind. Their average absolute magnitude is about —14.0; their light curves and spectral changes resemble each other very closely. What is more, the spectrum is entirely different from that of an ordinary nova. The spectrum of the second group is rather similar to that of an ordinary nova; it is what one would expect to find for a nova at a higher degree of ionization and at a higher temperature than usual. This group of supernovae is characterized by a lower maximum luminosity, the absolute magnitude having an upper limit of about —12, and considerable variation in the shape of the light curve.

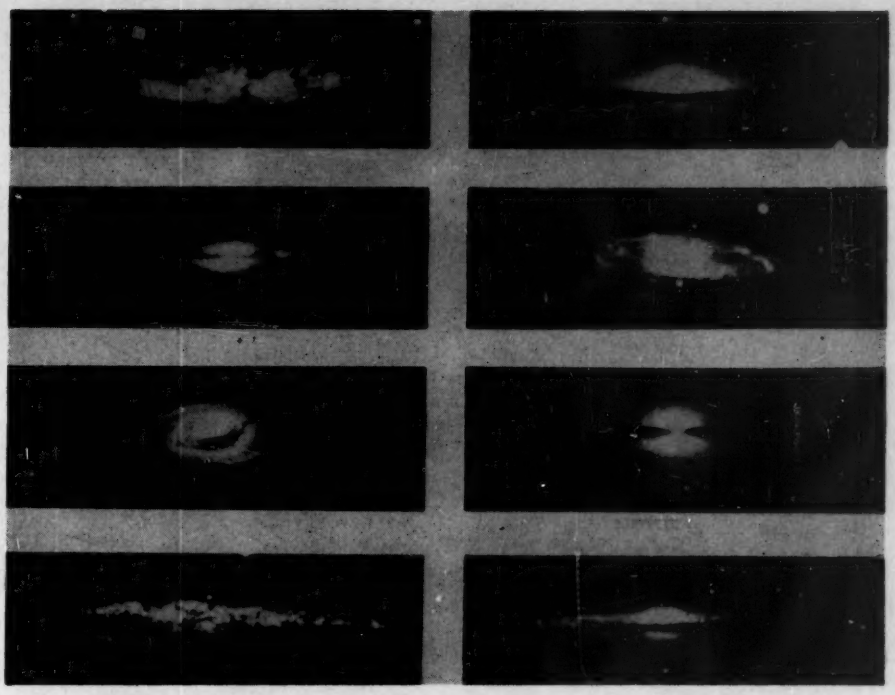
About 400 radial velocities of external galaxies are now known, over 300 of which are the work of Humason at Mt. Wilson. Radial-velocity determinations for objects which are members of a cluster of galaxies have a prominent place in the program, both because of the velocity-distance relation and because they might tell us something about the nature of clusters. We should like to know if galaxies on the edge of a cluster move faster than the central ones, or if there is a variation depending on the type of galaxy. There is as yet no evidence of any correlation. It seems that we shall have to wait until the 200-inch telescope is put into operation before the presence or lack of correlation is established.

The rotations of about eight of the brightest galaxies have been determined spectroscopically. The Andromeda nebula and Messier 33, an open spiral, have been recently studied at the Lick Observatory by Babcock, Mayall and Aller, out to a considerable distance from the center. The different rates of rotation found for dif-

A group of exterior galaxies of contra types. Stephan's quintet, a cluster of five gal is sh at each faint spot of light to see if it is galaxy.

ferent parts of a galaxy may tell us something about the distribution of mass within a system, as well as about the total mass.

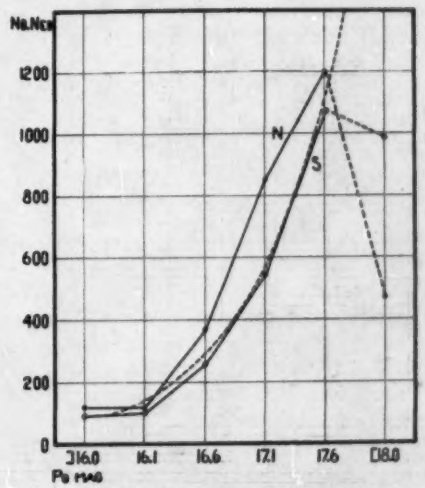
We are gradually gaining some knowledge of the masses of galaxies by four different methods: the mass-luminosity relationship applied to a whole system; the rotations just mentioned; the difference in radial velocity of components of double galaxies; and radial velocities of cluster members. We are forced to make too many dangerous assumptions when using the first method to have any faith in the mass values thus derived. The second method is the only one which gives an at all reliable value for an individual galaxy. The most probable average value, from the few cases we know, seems to lie between 10^{10} and 10^{11} times the mass of the sun. As to the third method, our instruments are not yet good enough to measure the radial-velocity differences accurately. The rather small differences found seem to indicate a tentative upper limit of about 10^{11} solar masses. In order to determine the average mass of cluster members, we must assume that the cluster is stable; that is, the gravitational attractions of the members on each other hold the cluster together. This method gives an average value of about 10^{11} solar masses. It is impossible to say more at the present time. We may note, however, that the mass value derived for cluster members refers to the *total* mass of a galaxy while the masses derived from rotations do not take into account the considerable contribution from the faint outermost portions. Thus, the former method should give a higher value for the mass.



Many types of galaxies are shown here. Some are nearly edgewise; some show considerable obscuring matter; some are irregular.

While we can determine the direction of rotation for a spiral galaxy, we cannot, without further evidence, find the direction of the spiral arms; that is, whether the free end of an arm points in the direction of rotation or away from it. This is because we cannot tell which edge of the galaxy is nearer to us. Further evidence is found only by observing the obscuration effects in edgewise galaxies. Some few suitable objects have been selected for study by Hubble and Mayall. These galaxies are viewed sufficiently on edge so that the central condensation seems to blot out part of the far side, but not enough to mask the structure of the arms. The direction of rotation was determined spectroscopically, and it was found that in each case the galaxy seemed to have its spiral arms pointing in the direction opposite to that of rotation; in other words, the nucleus drags its arms after it as the system rotates.

The idea of evolution of the observable universe is a tantalizing one. Both the different types of galaxies and their present distribution in space may be the result of an evolutionary process. The galaxies appear to have random space velocities of about 300 kilometers per second. We may infer that their relative positions have changed during the course of time, but we cannot tell to what extent. Beyond this, we have no direct evidence for or against an evolution, which leaves us free to speculate on the possible courses it might have taken, if it took place at all. From the red shifts in their spectra, we know that the galaxies appear to be receding from us; the farther away they are, the faster they appear to recede (the velocity-distance relation). If this expansion is real, then the galaxies must have started their outward motions some 2×10^9 years ago, or, from the evidence of uranium, at about the same time the earth was formed. If the red shifts do not indicate an expansion, certain factors point to a much longer time-scale, perhaps 10^{12} years.



A preliminary survey (1934) of the frequency of galaxies in 24 special regions in high northern and southern galactic latitudes. Each region covered nine square degrees and the average distance is of the order of 75 million light-years. The broken line shows the frequencies to be expected if the galaxies were distributed uniformly in space.

If evolution is supposed to account for the variety of types of galaxies, it may be

ntra types. On the back cover this month
gal , is shown. In the above picture look
it i galaxy. Yerkes Observatory photograph.

Elliptical Nebulae. **Those which appear globular are classified *E0*, and those which appear flattened the most (lenticular) are *E7*. Nebulae flatter than *E7* are spirals. Increasing the photographic exposure increases the size of the image of an elliptical nebula, but the shape remains constant. (From Hubble's *Realm of the Nebulae*.)**

that they develop because they are internally unstable. It is not yet clear what effect the instability would have on the direction of the spiral arms with respect to the direction of rotation. Therefore, there are no conclusive arguments to favor the development of spiral galaxies from elliptical ones over a development in the reverse direction.

There is also the possibility that close encounters between galaxies might produce a change of type. The instability would be caused by the mutual gravitational attraction, that is, by an external circumstance instead of an internal condition. If this explanation is true, the number of encounters must have been quite frequent in the past. Some light may be thrown on this question by a study of double galaxies. If the observed high frequency of double systems can be explained by captures, then the number of close approaches which did not result in permanent captures must be fairly high. E. Holmberg has made a statistical study of the clustering tendencies among galaxies and comes to the conclusion that the observed number of double systems may be the result of captures in a non-expanding universe during a period of about 10^{12} years. In this investigation, it was assumed that a certain portion of close encounters resulted in captures. In a forthcoming paper, he investigates the effect of the mutual gravitational attraction of two flattened galaxies during a close encounter. The orbits of individual mass-elements within the galaxies are reconstructed, piece by piece. It seems that under certain conditions a close encounter may result in a permanent capture. An interesting by-product of the investigation is the development of spiral arms during the encounter.

Development of a cluster of galaxies by successive captures is a natural extension of the capture theory for double systems. In order to reproduce the observed number of clusters, the average mass of a galaxy must be of the order of 10^{11} solar masses. According to this theory, one would expect to find a certain number of "temporary guests" in a cluster. They would be the galaxies which are passing through in hyperbolic orbits with high velocities. We actually find higher velocities within clusters than the average for galaxies outside.

These theoretical investigations are not designed to prove that our universe has evolved according to one scheme and no other, but rather to eliminate the impossible courses of evolution. Our knowledge of the fundamental, observable characteristics is still so scant that very few, if any, courses may be rejected as clearly impossible.

We may conclude this brief survey of recent studies by summing up the characteristics which are known to change with the sequence of types. This does not imply any evolutionary process. The galaxies are arranged in classes for the sake of convenience, beginning with the spheroidal form, passing to lenticular, and finally to open spirals. The changing characteristics are: increase in real size; decrease in surface brightness; decrease in the size of the central condensation; color change toward the blue end of the spectrum; increase in the number of supergiant stars; and increase in the luminosity of these stars. In case this list gives too great an impression of continuity in the classification, we may mention the fact that relatively extremely few galaxies are of a type intermediate between lenticular and distinctly spiral. Finally, the many questions which beset us in the investigation of the nature of galaxies cause us to say only, "Time [and future study] will tell."

An Observation of the Solar Corona

THE coronagraph is not generally used as a visual instrument, but it is customary procedure at the Fremont Pass Station at Climax, Colo., where the Harvard College Observatory coronagraph is located, to initiate a day's observations with a visual search of the solar limb for prominences or evidence of coronal light. This search is conducted either with an eyepiece carrying a red filter, or with a small visual spectroscope.

On April 20, 1941, 9:00 a.m. M.S.T., during the course of a routine examination of the solar limb, I found that a narrow region directly on the west limb showed, in the spectroscope, an emission that was probably the coronal line $\lambda 5303$. Actual estimates of wave length with the direct-vision instrument cannot be made more accurately than about 20 A.U. Observations of the same region about one hour earlier had not resulted in the discovery of this bright-line emission, although its faintness may have caused me to pass it by.

Within a few minutes the spectroscope showed the development of the prominence lines $\lambda\lambda 6563$, 4681, 5876, 5173-84. In about five more minutes the prominence was clearly visible in the eyepiece. Thereafter it rapidly increased in size and brightness, though at no time was it large and spectacular. The region of suspected coronal activity appeared to extend higher from the sun than the prominence, and to be centered perhaps a few degrees farther north. At first the prominence was entirely detached from the sun by perhaps 15,000 kilometers, but extended rapidly toward the sun as it enlarged, until it seemed to connect with the chromosphere.

One conclusion that may be drawn is that the coronal activity evidenced by the presence of a region showing $\lambda 5303$ was physically associated with the subsequent formation of a prominence. Nevertheless, one must state such a conclusion, drawn from a single observation, with the greatest of reservations. The apparent association of corona and prominence may have been entirely coincidental.

The motion picture film which was started within a few minutes of the prominence formation showed no direct evidence of coronal activity. Our failure to record the corona is not surprising, because the film proved to be somewhat underexposed from the standpoint of coronal records. Visual observations were not possible after the start of the film; one hour later the sky had clouded.

WALTER O. ROBERTS
Fremont Pass Station

BEGINNER'S PAGE

By George V. Plachy

The Moon—Part II: *Craters, Mountains, and "Seas"*

LAST month on this page we began a general discussion of the physical characteristics and appearance of the moon.

The naked eye sees large, irregular dark areas and bright patches scattered over its face. Through a small telescope or field glass the lunar surface presents a sight unique among astronomical objects. The principal topographical features are classified as follows:

(a) **Craters**—large and small circular areas, distributed at random, which give the surface a pitted appearance.

(b) **Mountains**—these mostly grouped in ranges or chains, although there are several conspicuous isolated peaks.

(c) **Maria or "seas"**—extensive, relatively flat plains, but containing **no** water; their dark hue is due principally to their low reflecting power.

(d) **Rays**—long, narrow, bright streaks diverging from several of the larger craters.

(e) **Rills**—narrow crevices, sometimes hundreds of miles long.

Of all the strange lunar formations, the craters are by far the most numerous. It is estimated that somewhat more than 40,000 are shown on photographs of the half of the moon facing us! Many craters have interiors almost level with (or even above) the outside surface, and so are not actually depressions but merely **walled plains.** Clavius, one of the largest of these latter, is 142 miles in diameter and has walls 12,000 feet high. Other craters are actually huge pits, like Newton, the largest, which is 23,800 feet deep and 143 miles across. The craters range in size down to the smallest dots visible in any telescope—about 200 yards across. The magnificent craters Copernicus and Tycho, each about 55 miles from rim to rim and 12,000 feet deep, are among the best known of all, because of the networks of mysterious bright rays or streaks which originate just outside their walls and spread out in all directions to distances of hundreds of miles, traveling unbroken straight paths across other craters, mountains, and plains. Tycho's rays may be traced a thousand miles to the very edge of the moon! The rays cast no shadows and are distinguishable only by their lighter color. Their origin is still shrouded in mystery. Copernicus is also noted for the conspicuous group of eight peaks clustered within its walls, and casting long, and striking, shadows across the crater floor.

Crater Theophilus, 64 miles in diameter, could easily hold the metropolitan area of New York City, while the great walled plain Schickard is considerably larger in area than the entire state of Vermont. An observer at the center of Schickard's 150-mile bowl would not be able to see its surrounding walls because of the curvature of the moon itself!

The brightest region on the moon is in the crater Aristarchus, 28 miles in diameter and 7,000 feet deep. This crater has a fine central peak. Two of the darkest spots on the lunar surface are the floor of the crater Plato and within the walled plain Grimaldi.

The craters seem to have been formed in rather random fashion and at various times, as many overlap others or lie entirely inside, and some show evidence of disintegration in remote ages past. Recent study of the question of the origin of craters indicates that **both** the impact of large meteorites and volcanic activity have contributed to the creation of these puzzling formations. Within recent times, however, not the slightest trace of any change in the moon's physical features has been conclusively established. Yet there have been interesting reports of changes of color in the floor of Plato, the "appearance of smoke" near Theaetus, snow in the crater Theophilus, "a minute point of light" seen near Agrippa, and changes in the form of the peak Linné and within the crater Eratosthenes.

The most prominent mountains are found in the three chains known as the Apennines, the Caucasus, and the Alps, which form the western boundary of Mare Imbrium. The Apennine range is nearly 500 miles long and contains more than 3,000 major peaks—the highest, Mt. Huygens, towering 18,500 feet above the adjacent plains! Due to the absence of erosive influences (water and wind), the mountains are severely jagged, and there are numberless valleys with almost vertical walls. The highest mountains are in the Leibnitz range and rise to nearly 25,000 feet, a little less than our own Mt. Everest. This range may be found near the lunar south pole, which appears at the top of photographs taken with an inverting (astronomical) telescope.

The major part of the moon's surface is covered by areas figuratively named maria, or "seas." These are the darker portions which even the unaided eye may see, and which are fancifully imagined to represent the "man in the moon," or a very long-eared donkey. The greatest is Oceanus Procellarum, which contains two million square miles and covers about one sixth of the entire lunar sphere. The hills bordering the northeast side of Sinus Iridum, or Bay of Rainbows, present a particularly beautiful aspect when the moon is about 11 days old. At this time the bay itself is darkened, but light still remains on the adjacent range of hills, which seems to become detached at its easterly end and raised entirely off the moon's surface, a filament of the lunar landscape trailing off into space.

The maria and the ray systems are best seen when the moon is full, while the craters and the mountains appear most distinct at the intermediate phases, when the **terminator** (boundary between the sunlit and dark portions) is close to the feature under observation. At this time the shadows are longest across the line of sight. Lunar heights and depths are determined by measuring the lengths of these shadows.

The conspicuous craters are named for famous astronomers or philosophers, many mountain ranges, for terrestrial ranges, and the maria have chiefly fanciful or poetic designations. The names of most of the prominent parts of the moon's surface were assigned by the astronomer Riccioli, of Bologna, who published the first accurate lunar map in 1651.

For the amateur astronomer who has access to a small telescope, or binoculars of six or eight power, the sight of the moon's varied features is a delight. A thrill akin to discovery awaits the beginner who will spend a little time observing and charting the lunar landscape.

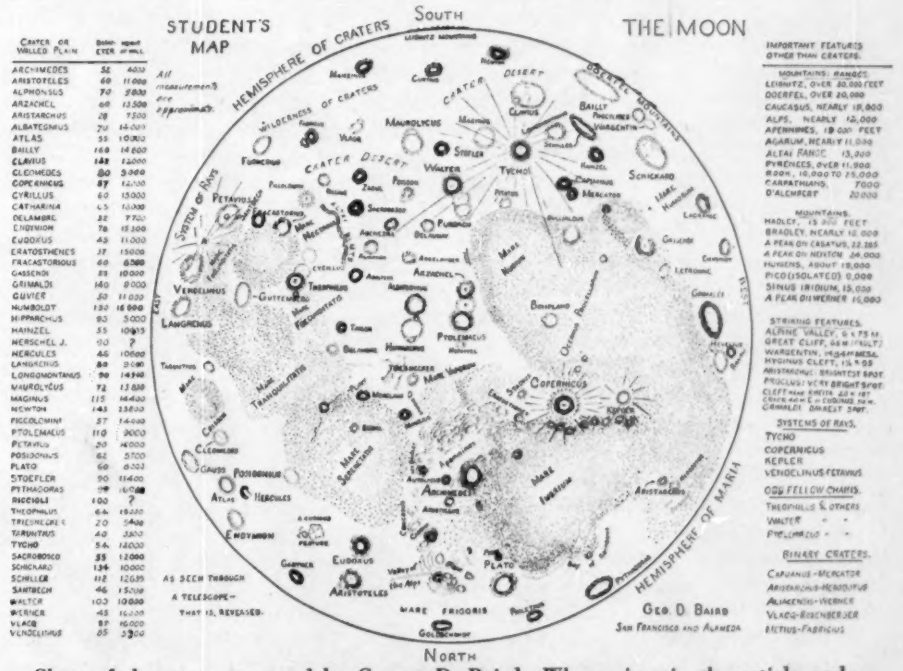


Chart of the moon prepared by George D. Baird. Where sizes in the article and the chart do not agree, observers have measured between slightly different points on the lunar feature involved.

Amateur Astronomers

Herbert M. Harris entering his new observatory, *Terraceleste*. Note the well-constructed sliding roof, and the refractor projecting above it.

A STARGAZER'S WORKSHOP

By Adeline Dunton

WITHIN sound of the booming foghorn of historic Portland Head Light on the Maine coast, an enthusiastic amateur astronomer has recently completed his new observatory, Terraceleste, dedicated, however modestly, to a greater beacon than that of the lighthouse—to the lamp of science which illuminates stellar laws and mysteries.

It is fascinating to hear Herbert M. Harris tell of the development of his hobby, which is now one of the keenest interests of his life:

"About five years ago, a friend asked me to join an astronomy club which was being formed. I said I knew nothing of the subject and was not enthusiastic on the idea. But he spoke of grinding a mirror, a mechanical process that interested me, and I saw it at his home. Well, he let the bars down for me and now I am thankful to him for it. I got a small book on astronomy and began to study; then my wife bought me a book on constellations and I went at it with field glasses. I got interested in observing double stars, learned that they are predominantly blue, and that led to the subject of colors of stars. It just intrigued me, so I bought another book—been buying them ever since."

He soon outgrew the field glasses and at first thought of making a telescope. He went up to Harvard College Observatory for information, but it happened that Leon Campbell, Recorder of the A.A.V.S.O. there, showed him a 3⅜-inch Bardou refractor which Harris decided to purchase. He says:

"I had a wonderful time with it; observed and recorded more than 200 double stars and learned about 500 stars by name or letter. Then Dr. William L. Holt, of Scarboro, Me., got me interested in variable stars. You know you look at them one night and they may be of the 6th magnitude, while a month later they may be of the 10th. I got the official charts and began to make records of my observations for the A.A.V.S.O. They were accepted, and soon after I became a member of that organization."

> . . .
> *Up the dome of heaven,*
> *Like a great hill,*
> *I watch them marching*
> *Stately and still,*
>
> *And I know that I*
> *Am honored to be*
> *Witness*
> *Of so much majesty.*
>
> Sara Teasdale

A year later Harris sold his Bardou and bought what he calls "a real telescope," which is housed in the new observatory. This compact, cleverly designed building is situated on a ledge back of his new home and bolted to eight concrete piers. The roof opens in the center, each half sliding back on tracks over extending arms at the corners of the structure. A 50-year old railroad lantern atop a pyramidal post, wired for electricity, and a flight of concrete steps mark the approach, and a blue spruce indicates the beginning of landscaping. The place is fully electrified, with controls on a switchboard, and remote control from his home.

Of course, the center of interest is the impressive 6-inch Clark refractor, with a lens ground by Carl Lundin himself, who figured the famous Yerkes 40-inch glass. The steel pier is bolted and cemented to a 5-foot concrete block based in the ledge. There are friction clutches for quick motion, and slow-motion controls as well. The dew-cap is heated by electricity so the glass remains free of moisture.

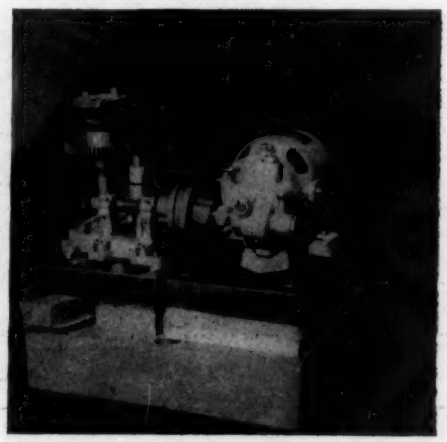
The various gadgets necessary for observation are stored in a small corner closet which is heated slightly by an electric warmer. His illuminated star-chart box has two small red electric lights—the red light does not affect the eye adversely during observing.

Together with his friend, Dr. L. W. Hadley, Mr. Harris built a driving machine which he says transgresses mechanical principles in minor ways but has the merit that it works. It consists of a variable-speed motor with worm gears, successively reducing the speed 40, 52, and five times. A long, vertical shaft and miter gears carry the motion to a worm gear on the telescope's polar axis, and this cuts the speed 207 times more—completing the reduction from 15,000 revolutions per minute to one revolution in about 24 hours. A patiometer does the final adjusting.

In 1938 Mr. Harris was a prime mover in founding the Astronomical Society of Maine, now having more than 30 members. He is president this year. The organization meets once a month, and topics studied range from the solar system to astrophysics, from ancient to modern astronomers, from the nearby moon to distant galaxies.

Asked which of his various achievements in his avocation came hardest, Mr. Harris replied, "I taught myself everything I know about it from books. I think the hardest things were understanding sidereal time and how to orient a telescope."

Many an individual owes his first conception of the splendor of Albireo or the glowing mystery of the Pleiades to this "plodding amateur," as he calls himself, who has entertained more than 2,000 people with his telescope, always



The homemade driving mechanism for Mr. Harris' telescope.

answering their many questions for good measure.

Garruth's poem beginning, "A fire-mist and a planet," hangs on the wall of Terraceleste. Mention of it made the amateur astronomer thoughtful. "I'm not a churchman," he said, "but when I'm observing those stars I feel near to God."

AMATEUR ASTRONOMERS ASSOCIATION
New York City

Lectures: On December 3rd, "An Amateur's Observatory," by Paul S. Watson, Maryland Academy of Sciences. On January 7th, **Symposium:** "The Sun and the Earth," by AAA instructors. All lectures are held at 8:15 p.m. in the American Museum of Natural History. Guests are welcome to these meetings, which are followed by outdoor observing with telescopes, if the sky is clear.

Field Trip: The visit to Rutherfurd Observatory of Columbia University on November 11th was attended by over 60 members. A second trip is being planned for those who could not be accommodated the first time.

Christmas Carnival: An evening of astronomical and social entertainment on December 13th.

Technical Committee: This is being formed to coordinate practical study and observing of members and to publish their papers. Other societies are invited to write George V. Plachy, secretary, to arrange cooperative activities.

JUNIOR ASTRONOMY CLUB
New York City

Dr. Luigi Jacchia, astronomer connected with Harvard College Observatory, will speak on "Variable Stars," on December 6th.

A special treat is in store for club members when one of their own number—selected after a series of competitions—speaks on a subject of his own choosing—December 20th. All meetings are open to the public and start at 8:00 p.m. in the American Museum of Natural History.

DETROIT SOCIETIES RATIFY A.A.L.A. BY-LAWS

Members Nos. 1 and 2 of the Amateur Astronomers League of America, when it is finally organized, will be the two astronomical societies in Detroit, Mich. Early in November the Northwest Astronomical Society reported ratification of the proposed by-laws and submitted entry fee of three dollars. Soon thereafter the Detroit A.S. followed suit, so these become the first two groups to report final action.

Other societies have requested reprints of the by-laws (which are now available in any quantity), and it is expected that their recommendations will be received soon. January 1st has been set as the time by which all revisions in the by-laws should be proposed. All interested societies are urged to act at the earliest possible moment, and to report their action to C. A. Federer, Jr., Harvard College Observatory, Cambridge, Mass.

DO YOU KNOW?

By L. J. Lafleur

TIME QUIZ

I. Score four points for each question correctly answered, and one point for each question where you do not attempt to select the answer.

1. By local time is meant that
   a. there is local option as to standard or daylight saving time
   b. noon is determined by the local southing of the sun
   c. standard time of the local zone is used
   d. the clock is advanced one hour
2. The length of the solar day is not affected by
   a. the eccentricity of the earth's orbit
   b. the inclination of the earth's orbit
   c. the real motion of the sun
   d. the gravitational action of the moon
3. After millions of years, the day will have
   a. grown longer
   b. grown shorter
   c. grown shorter, then longer
   d. remained constant
4. At present, the tropical year is
   a. growing longer
   b. growing shorter
   c. sometimes longer, sometimes shorter
   d. remaining constant
5. The true sidereal day (period of the earth's rotation), compared to the sidereal day, is
   a. longer
   b. shorter
   c. sometimes longer, sometimes shorter
   d. the same
6. The equation of time is
   a. the difference between apparent solar time and mean solar time
   b. solar time expressed in terms of sidereal time
   c. the ratio between the true month and the true year
   d. the spatial distance equivalent to a second of time
7. The international date line is the line of demarcation between
   a. day and night
   b. day and day
   c. midnight and morning
   d. a.m. and p.m.
8. Time is defined and measured by
   a. the intervals between sunrise and sunrise
   b. the intervals between noon and noon
   c. the velocity of light
   d. the motion of bodies
9. Universal Time is so related to Greenwich Civil Time that
   a. they were once the same but are now different
   b. the first is sidereal, the other tropical
   c. the first is tropical, the second sidereal
   d. they are identical
10. The calendar we now use is
    a. Roman
    b. Julian
    c. Gregorian
    d. Newtonian

II. Each of the numbers, a, 346.62; b, 354.367; c, 365.2422; d, 365.2564; and e, 365.2596, represents the number of calendar days in a certain type of year. Select the proper year for each from the list below (four points each).

Anomalistic year	Julian year
Calendar year	Lunar year
Eclipse year	Sidereal year
Tropical year	

III. The length of certain days is: a, 23h 56m 4.0905s; b, 23h 56m 4.0996s; c, 24h; d, 23h 59m 35s to 24h 25s; e, 24h 38m to 25h 6m. Select the most appropriate day for each from the list below (four points each).

Astronomical day	Mean solar day
Civil day	Sidereal day
Julian day	Solar day
Lunar day	True sidereal day

IV. Explain why each of the following statements is true (five points each).

1. According to the Einstein theory, time is not infinite.
2. Those who hold to the superstition of astrology must use a different year from the calendar year.
3. Mornings sometimes grow longer while afternoons grow shorter.
4. According to the principle of uncertainty, there is a limit to the measurement of time.

(*Answers on page 21*)

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BOOKS AND THE SKY

GLASS—THE MIRACLE MAKER

C. J. PHILLIPS. Pitman Publishing Corp., New York, 1941. 424 pages. $4.50.

THE amateur telescope maker's first inclination on picking up this book would probably be to consider it just what he had been waiting for; after skimming through it, he would think that it throws no light on telescope making, but that it would do him good to read it.

Although there are many parts of the book containing information of general interest, the author, connected with Corning Glass Works, intends it to be read with profit by civil, mechanical, chemical, electrical, and industrial engineers, and by architects. Therefore, **Glass—the Miracle Maker** lies intermediate between a technical but non-mathematical treatment of the subject, and an interesting running account of the multifarious uses of glass in every field. The author does his difficult task well. The book throughout shows evidence of careful composition, organization, and selection of material. The historical portions, although not always entirely correct, serve to increase the interest for the general reader.

Chapters of special interest to advanced amateurs who have acquired a smattering of physics and chemistry are those on the chemical, mechanical, and physical properties of glass. The telescope maker will probably be interested in the shrunken 96 per cent silica glass similar in nature to fused quartz. This material is now several years old, and already has proved of great aid to chemistry. The discussion of the mechanical strength of glass and its relation to surface defects and scratches will be of interest to the telescope maker. Of course, the chapters dealing with applications of glass technology to everyday living will appeal to everyone.

The book is up-to-date, although for defense reasons certain developments at Corning and elsewhere have been omitted. Prominent authorities in glass technology have been freely consulted, as well as the many manufacturers of glass in this country. The bibliography at the end of each chapter will be of use to students in neighboring fields.

The subject of optical glass is treated from the astronomer's standpoint in only a sketchy fashion. Even strikingly new developments like the non-silicaceous glasses produced by Morey and others have received only a scanty treatment, again probably for defense reasons. Although the details of production of plate and other widely used industrial types of glass are discussed in detail, the peculiar difficulties of manufacturing optical glass are neglected. The interesting search for optical glasses with reduced secondary spectrum and a wider range of other properties receives no attention.

The book contains a large amount of straightforward factual data on the hardness, strength, brittleness, electrical resistance, and so on, of many kinds of glasses. The reactions of glasses to various chemicals will perhaps be of aid to amateurs who may too zealously try to clean their camera or telescope lenses.

One finds a few light-hearted references to astronomy in connection with the need to mention telescopes as an application of glass. The 200-inch is described briefly, but the problems connected with the production of the large disk are for the most part omitted.

Selection of the Scientific Book Club for September, **Glass—the Miracle Maker** is neatly bound in a gray and rose cover, and for contents and appearance will be a credit to any bookshelf.

JAMES G. BAKER
Harvard College Observatory

AMATEUR TELESCOPE MAKING

Fourth Edition, Third Printing. ALBERT G. INGALLS, editor. Munn and Co., Inc., New York, 1941. 497 pages. $3.00.

THIS delightfully topsy-turvy book needs no introduction. The latest changes are insufficient in number to justify a fifth edition. The continued sale of the second printing having exhausted the supply, the editor has taken the opportunity of making several important additions and alterations for the third printing. Some 76 reviews of the outstanding books in optics and astronomy have been incorporated. There are new lists of amateur groups and astronomical societies and publications. A new index, prepared by Cyril Wates, of Edmonton, Alberta, will be of great aid in using the book for reference.

The book still contains a small number of misprints, most of which are known to the publishers. Beginners may wonder what an "aplantic" O.G. is (p. 470), and probably will want to make one.

As the editor readily confesses, owners of previous printings need not invest in the new one. Some of the factual material could be brought up-to-date. For example (p. 302), Bausch and Lomb, Corning Glass Works, Pittsburgh Plate Glass, and the Bureau of Standards are engaged in making optical glass, although defense priorities make it almost unobtainable.

As suggestion for future editions of **Amateur Telescope Making** and **A.T.M.A.**, it seems to me that the Lyot coronagraph would serve as an attractive problem for the amateur. The optical surfaces involved must not only be exact, but must be free from scratches, pits, and even the finest sleeks. The quartz monochromator would tickle the fancy of the advanced amateur. Hale's article on the spectroheliograph could be supplemented by a description of the McMath-Hulbert and Lyot equipment. In the advanced work more attention could be given to the design of camera lenses, refractors, and eyepieces.

Needless to say, the book remains a storehouse of valuable information. The number of man-hours of endeavor that have gone into the various hunches, hints, methods, and so on, must be truly tremendous.

JAMES G. BAKER
Harvard College Observatory

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NEW BOOKS RECEIVED

GLASS, THE MIRACLE MAKER, *C. J. Phillips.* 1941, *Pitman.* 424 pp. $4.50.

A complete treatise for industrial engineers, written in a manner to make this fascinating subject clear to the layman as well. Reference is made to the 200-inch telescope and the use of glass in optical instruments.

THE MORNING STAR RISES, *Maud Worcester Makemson.* 1941, *Yale.* 301 pp. $5.00.

Subtitled "An Account of Polynesian Astronomy," this book presents the fund of knowledge of astronomy and related sciences known to the islanders, and its effect on their migrations, legends, beliefs, and daily lives.

AMATEUR TELESCOPE MAKING, edited by *Albert G. Ingalls.* 1941, *Munn.* 497 pp. $3.00.

Not a new edition, but the 4th edition, 3rd printing, of this invaluable handbook for the telescope maker. Owners of a previous edition will not need this printing, the editor says, but new material has been added which brings the book up-to-date.

ANSWERS TO DO YOU KNOW?

(*Questions on page* 19)

I. 1, b; 2, c; 3, a; 4, b; 5, a; 6, a; 7, b; 8, d; 9, d; 10, c.

II. a, eclipse; b, lunar; c, tropical; d, sidereal; e, anomalistic.

III. a, sidereal; b, true sidereal; c, mean solar; d, solar; e, lunar.

IV. 1. According to the most common interpretation of the Einstein theory, space-time is recurved upon itself in such a way that any "geodesic," such as a time line, meets itself in a finite circle.

2. According to this most ancient of superstitions, a controlling factor of "fate" is the position of the sun in the several traditional "houses" of the ecliptic. But the period involved is the sidereal year, not the calendar or tropical year.

3. This is due to the difference between the solar and mean solar day, so that the southing of the sun occurs earlier by clock time each day from September through December.

4. According to this principle, there is a definite limit to the possible accuracy of measurement of space and time. The precise limit for time, however, will vary inversely with the limit for space, since the ultimate limit is measured as the product of the two factors.

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PARADOXICAL PARABOLAS

ACCORDING to customary procedures, the process of "figuring" a mirror is that of producing, first, a well-polished spherical surface; then deepening the center by means of long strokes until a paraboloidal surface is achieved. The techniques of stroking, and so on, to produce desired changes in a mirror's curvature, are well covered in current literature, and we shall not devote this space to a description of them, but shall concern ourselves with a discussion of what changes it is necessary to make to produce the desired paraboloid.

Since we cannot know, from moment to moment, what is taking place on the mirror surface, and can only discover when testing what the last period of work has accomplished, it frequently happens that the process of deepening is inadvertently carried too far. Convention indicates the necessity of reverting to short strokes to "bring it back" to paraboloidal form. As all mirror makers know, this is a much more difficult procedure than deepening, for it is hard to control zonal progression with short strokes; also, roughness is likely to result.

We are indebted to Allyn Thompson, of New York, for the somewhat unconventional suggestion, "Why not deepen it more instead of trying to bring it back?" Mr. Thompson acquired his idea from study of the Foucault test. If the knife edge is placed at the center of curvature of the "70 per cent" zone, the familiar doughnut shape (see W. Everest in **Amateur Telescope Making** on the doughnut series) is seen on the mirror, and the maker usually decides from an examination of this whether the curvature is too small or too great, and takes long or short strokes accordingly. If, however, the knife edge is placed at the center of curvature of the outer zone, the mirror appears to have a deep hole, and if the knife edge is at the center of curvature of the center of the mirror, an apparent plateau results. Why, asks Mr. Thompson, can we not take this latter appearance of the mirror as representing the actual curvature, and proceed to carve away this plateau with long strokes?

Although the suggestion at first sounds absurd, a careful examination leads to the conclusion that it is quite well founded.

Given any arbitrary setting of the knife edge, we can observe an apparent surface curvature of a mirror according to the well-known interpretation of shadows discussed at length in many articles on this method of testing. The apparent curvature thus seen is the curvature **relative to a sphere whose center is at the knife edge.** If the mirror is spherical, all zones darken evenly at a single setting of the knife edge, and we conclude that the reference sphere is tangent everywhere. Given a setting of the knife edge corresponding to the center of a sphere which is tangent at, say, the 70 per cent zone, we find that the central portion of the mirror (if it is a paraboloid) is more sharply curved than the reference sphere, and hence the center of its reference sphere lies nearer the surface, and it appears concave to the eye; conversely, the outer region is less sharply curved, the center of its reference sphere lying farther from the mirror, and it appears convex to the eye.

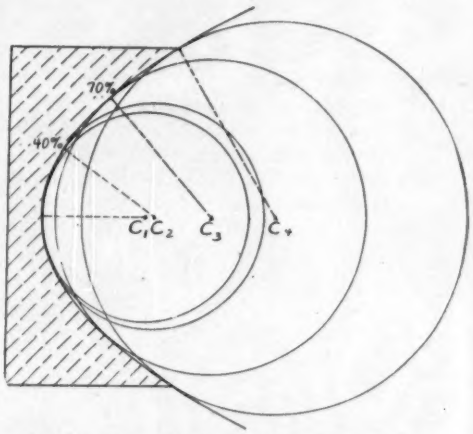

Fig. 1. What the Foucault test measures. C_1, C_2, C_3, C_4, are settings of the knife edge, and represent the centers of the spheres which are tangent to the mirror surface at the center, 40%, 70%, and edge zones, respectively.

Now, let us consider the outer edge of a mirror and the sphere tangent thereto (Figure 2). (We will hereafter discuss circles and parabolas instead of spheres

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and paraboloids, since it will be equally valid and more convenient.) One parabola can be made tangent to a given circle at two specified points, the position of the axis being fixed. This is the parab-

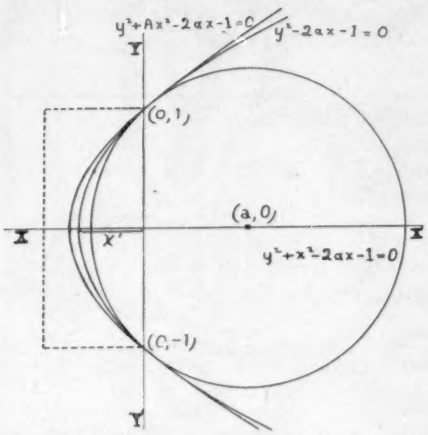

Fig. 2. Only one parabola but many hyperbolas are tangent at (0, 1) and (0, —1) to the circle whose center is (a, 0).

ola we are attempting to produce. There are an infinite number of ellipses and hyperbolas which can be made so tangent (also 3rd- and higher-degree curves, which we will ignore). However, there are an infinite number of parabolas which can be **passed through** our specified points. These are not tangent to our given circle at these points, but each one is tangent to **some** circle there.

Hence, we can produce **some** parabola which is a little deeper than any curve our mirror may have, and this parabola will be tangent at the edge of the mirror to **some** reference sphere. The method suggested by Mr. Thompson is therefore valid, and it remains only to inquire how much this new reference sphere will differ from the old one, or, in effect, how much the focal length will be changed. The proportionate change in focal length will be equal to the proportionate change in the depth of the mirror. Since it is almost inconceivable that the latter could be greater than 1/10 of one per cent, it follows that we will not change a 50-inch focal length by more than 1/20 of an inch by this procedure.

The mathematical proof is given below. For those who require more practical demonstration, Mr. Thompson assures us that he has produced parabolas on several "too-deep" mirrors by his long-stroke technique. This should prove a considerable boon to those many A.T.M.s to whom short-stroking is a hobgoblin producing zones and roughness.

EDITOR'S NOTE: For a mathematical proof of the above, we proceed as follows (see Figure 2):

I. Only one parabola can be made tangent to a given circle at two specified points, the position of the axis being fixed.

Let the given circle have center at (a, 0) and let the two points be (0, 1) (0, —1). Then the equation of the circle is

$$x^2 + y^2 - 2ax - 1 = 0 \qquad (1)$$

and its derivative is $\frac{dy}{dx} = \frac{a - x}{y}$

and $dy/dx = a$ at the point (0, 1). (2)

The parabola, with axis on **XX'**, passing through (0, 1) has the equation

$$y^2 + Ax - 1 = 0 \qquad (3)$$

and its derivative is $\frac{dy}{dx} = -\frac{A}{2y}$

and $\frac{dy}{dx} = -\frac{A}{2}$ at the point (0, 1). (4)

Now, for tangency it is necessary that (2) = (4), or A = —2a, whence the desired parabola has the equation

$$y^2 - 2ax - 1 = 0 \qquad (5)$$

There are no arbitrary coefficients, therefore there is only one such parabola. The validity for the point (0, —1) follows from considerations of symmetry.

II. There are an infinite number of hyperbolas which can be made tangent to a given circle at two specified points, the position of the axis being fixed.

Let the circle be as in I. The hyperbola, with axis on **XX'**, passing through (0, 1), has the equation

$$y^2 + Ax^2 + Bx - 1 = 0 \qquad (6)$$

and its derivative is $\frac{dy}{dx} = -\frac{2Ax + B}{2y}$

and $\frac{dy}{dx} = -\frac{B}{2}$ at the point (0, 1). (7)

Now, for tangency it is necessary that (2) = (7), or B = —2a, whence the desired hyperbola has the equation

$$y^2 + Ax^2 - 2ax - 1 = 0 \qquad (8)$$

There is an arbitrary coefficient, A, therefore there are an infinite number of hyperbolas satisfying the conditions.

III. There are an infinite number of ellipses which can be made tangent to a given circle at two specified points, the position of the axis being fixed.

The general equation for the ellipse with axis on **XX'** is the same as for the hyperbola, therefore the proposition follows from II.

IV. There are an infinite number of parabolas which can be passed through the points specified in I.

This follows from equation (3) and the closing argument of II.

V. There is a circle tangent to any given parabola passed through the specified points.

This follows from the fact that the coefficient a in equation (5) may be considered arbitrary, and an equation similar to (1) written for the desired circle.

VI. The change in focal length will be inversely proportional to the change in the depth of the mirror.

The focal length is proportional to a, and therefore, to A, in equation (3).

The depth of the mirror is equal to the minimum value of x in equation (3), viz., its value for y = 0. This is

$$x' = +\frac{1}{A}$$

Hence, the change in a is inversely proportional to the change in x', or, the focal length grows proportionately shorter as the depth of the mirror increases.

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SKY-GAZERS EXCHANGE

Classified advertisements accepted for this column at 30c a line per insertion, 7 words to the line. Minimum ad 3 lines. Remittance must accompany orders. Address Ad Dept., Sky and Telescope, Harvard College Observatory, Cambridge, Mass.

6" reflector with cell, tube and eyepiece holder for sale. Mirror guaranteed. Have larger scope. Clark J. Wells, Box 1325, Coolidge, Ariz.

For Sale: 2¾", 41" focal length, refractor by Dollond, on tripod mount. First-class condition, one terrestrial and two celestial eyepieces. $120.00.

For Sale: 3¼", 54" focal length, refractor by Bardou; tripod mount, finder, one terrestrial and three celestial eyepieces, sun-cap for low-power eyepiece. $175.00.

A Real Bargain: 4¼" Byrne refractor; equatorial mounting with circles and clock drive on iron pier; finder and six astronomical eyepieces, sun and star diagonals. This first-class glass is in very fine condition.

M. Rasmussen, 360 Guy Park Ave., Amsterdam, N. Y.

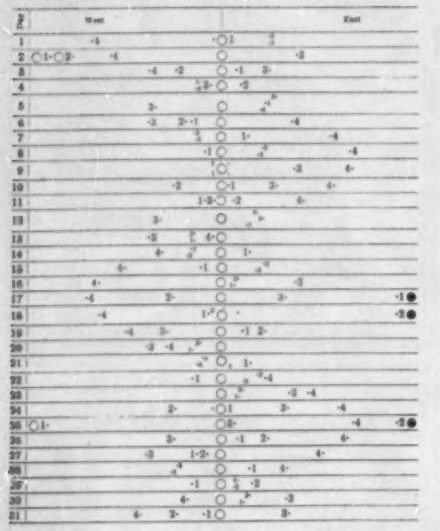
GLEANINGS is always open for comments, contributions, suggestions, and questions, from its readers. We are here to serve, in every possible way, those of the telescope-making fraternity who are among the readers of *Sky and Telescope*.

OBSERVER'S PAGE

By Jesse A. Fitzpatrick

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below at 12:15 a.m. E.S.T. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the **American Ephemeris.**



Moon **IV** will be in superior geocentric conjunction at 1:28.5 a.m. E.S.T., December 21st, appearing at that moment just north of the disk. It will be in inferior geocentric conjunction at 6:18.2 p. m. E.S.T., December 12th, appearing south of the disk. Following this conjunction, all moons will be west of the primary.

On December 19th, all moons will be west of the primary and on the 22nd all will be on the east side. Just before midnight and subsequent to the conjunction of **I** and **II** they will be in numerical order, **I** being nearest the disk.

During the evening of December 1st, the amateur will have a rare opportunity to compare the motions of moons **I** and **II** and their shadows while in transit across Jupiter's disk. The table shows the moments of ingress and egress in E.S.T. of the moon and shadow.

	I	II
Moon, ingress	10:47 p.m.	10:51 p.m.
egress	12:57 a.m.	1:30 a.m.
Duration	2h 10m	2h 39m
Shadow, ingress	10:36 p.m.	10:29 p.m.
egress	12:47 a.m.	1:10 a.m.
Duration	2h 11m	2h 41m

Due to the inclination of Jupiter's polar axis to our line of sight at this time, the transits of these satellites do not traverse a distance equal to the equatorial diameter, 88,700 miles. Instead, the apparent distance traveled by **I** is 85,000 miles, since its path is slightly south of the center of the disk, and that of **II** is 82,000, being still farther south. The speed of **I** is 39,000 miles per hour, and in 2 1/6 hours it will travel 85,000 miles. **II** moves at a speed of 31,000 miles per hour, and requires 2⅔ hours to travel 82,000 miles. These figures are approximate, but give a check on the time intervals for the transits listed above. It will be noted that the ingress of the shadow precedes the moon in each case. After opposition on December 8th, this order will be reversed.

On December 3rd, for a period of 58 minutes after 6:25 p. m. E.S.T., Jupiter will appear to be accompanied by only one satellite, moon **IV.**

PHASES OF THE MOON

Full moon	Dec. 3, 3:51 p.m. (E.S.T.)
Last quarter	Dec. 11, 1:48 p.m.
New moon	Dec. 18, 5:18 a.m.
First quarter	Dec. 25, 5:43 a.m.

THE PLANETS IN DECEMBER

Mercury will be too near the sun for observation.

Venus will reach its phase of greatest brilliancy at 8:00 p. m. E. S. T., December 28th. The stellar magnitude will be —4.4, and 27 per cent of the disk will be illuminated. Through a telescope the planet will resemble the crescent moon when about 4½ days old. The planet will be only four minutes south of the ecliptic at that time, and will cross to the north side on the following day. It will be in Sagittarius for the first four days and in Capricornus for the balance of the month.

Earth, on December 22nd at 0:45 a.m. E.S.T., will reach heliocentric longitude 90°, and winter will begin in the northern hemisphere.

Mars will be in Pisces, and its motion progressive. It will cross from the south to the north side of the ecliptic on December 5th. The stellar magnitude at the end of the month will be 0.0 and angular diameter 10″.3. Since the disk's illumination at that time will be only 89 per cent, it will present a decidedly gibbous appearance.

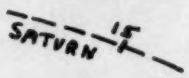
Jupiter, in Taurus, will be in opposition on December 8th, 380 million miles from the earth. Its motion will be retrograde.

Saturn, in Taurus, is in retrograde motion, and will be very close to Aries' boundary at the end of the month.

Uranus. See diagram in the November issue.

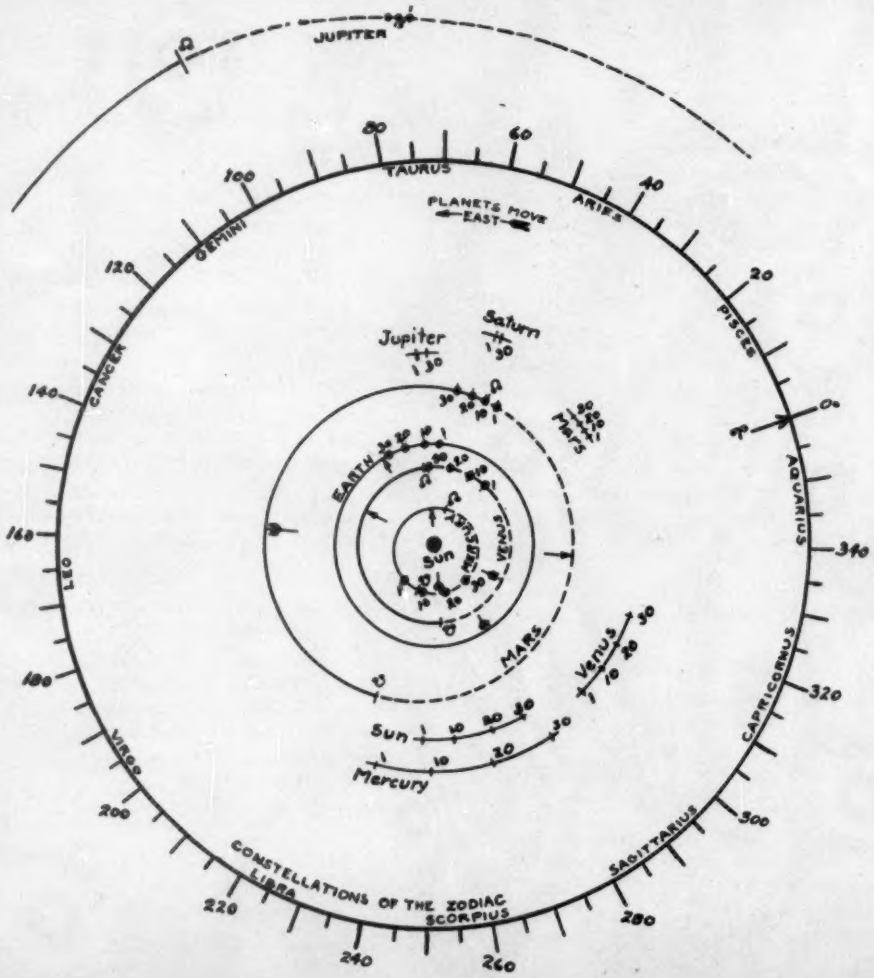
Neptune is in Virgo and very close to the autumnal equinox, in a field that is free of any but very faint stars.

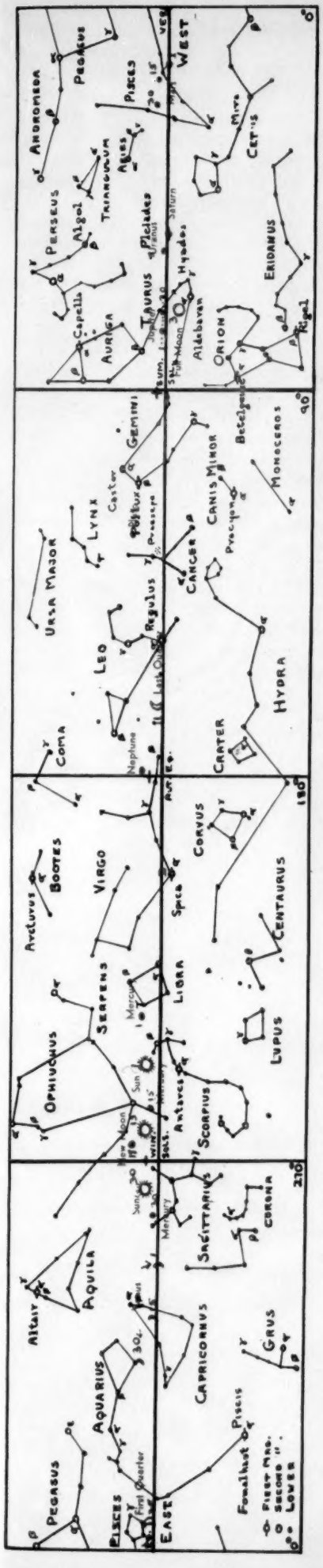
In the chart below, the orbits of the planets are drawn to scale, and on the orbits are



shown the heliocentric positions of the planets. Ascending and descending nodes are also marked by the usual symbols.

For convenience, *geocentric* positions are also shown. Suppose, instead of the sun, we had the earth at the center of the diagram. Then straight lines drawn from it through the short arcs just outside the Mars orbit show the positions of the planets against the zodiac at the various dates. Chart by Sylvan Harris from *The Amateur's Planetarium.*





THE APPARENT POSITIONS IN THE HEAVENS OF THE SUN, MOON, AND PLANETS.

OCCULTATIONS—DECEMBER, 1941

Local station—lat. 40° 48'.6, long. 4h 55.8m west.

Date	*Mag.*	*Name*	*Immersion* E.S.T.	*P.**	*Emersion* E.S.T.	*P.**
Dec. 6	6.2	74 B Geminorum	1:58.5 a.m.	44°	2:56.1 a.m.	327°
6	5.6	162 B Geminorum	9:23.9 p.m.	92°	10:34 p.m.	269°
12	6.5	27 B Virginis	5:18.6 a.m.	118°	6:40.3 a.m.	297°
13	6.5	91 G Virginis	6:28.8 a m.	143°	7:41.1 a.m.	272°
27	4.5	ξ′ Ceti	4:01.8 p.m.	56°	5:18.4 p.m.	255°
29	6.4	3 B Tauri	0:38.2 a.m.	26°	1:22.4 a.m.	309°
30	1.1	Aldebaran	4:01.5 p.m.	39°	4:51.6 p.m.	293°

*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

The combined occultation and visible conjunction of the star 130 Tauri, magnitude 5.5, during the evening of December 5th, will be unusual and very interesting to observe. At the instant of conjunction in right ascension of the moon and star, 8:32.3 p.m. E.S.T., at our local station, the star will be south of the moon's edge by a distance of one half of one per cent of the moon's diameter, about nine seconds of arc. Prior to this there will be an occultation for a very few minutes, but it will be practically impossible to predict the moments of immersion and emersion with any degree of accuracy due to the Doerfel mountains, which are on the edge of the moon at this point. The star will appear to travel along the edge of the moon, disappear for a few minutes, and reappear just east of the south point, the conjunction line. The Doerfel mountains, among the highest on the moon, project beyond the theoretical circumference in this vicinity, and so could advance the immersion or retard the emersion as much as a minute or two. The position angle of the moon's axis at this time will be 358 degrees, making the south point on a line from the moon's center through the crater Moretus.

GEMINID METEORS DUE

On December 12th and 13th we may expect the Geminid meteors. The finest meteor display I have ever witnessed was this shower in 1938. At my tropical island winter home we watched the Geminids fall from 7 p.m. to 1 a.m. and counted better than 60 an hour. Visibility was nearly perfect.

MINIMA OF ALGOL

Dec. 4	3:53 a.m. (E.S.T.)
7	0:43 a.m.
9	9:32 p.m.
12	6:22 p.m.
24	5:38 a.m.
27	2:27 a.m.
29	11:16 p.m.

THE ECLIPTIC CHART

at the left is drawn with the ecliptic as its central line, instead of the celestial equator. Perpendicular to this are lines marking celestial longitude. The positions of the sun, moon, and inner planets are shown for the beginning, middle, and end of the month. The outer planets do not change materially from the positions shown during that time. On the next page is the star chart for this month.

VENUS AS THE CHRISTMAS STAR

(*Continued from page* 11)

them by passing well **to the west** until within a few miles of the Mediterranean Sea. It then turned south through the Sharon Plain and continued over this level country to Egypt and the land of the Midians.

Travelers to Jerusalem left the highway at Lydda, the present city of Ludd, and journeyed a further 25 miles in a direction **somewhat south of east** to reach their destination. Just a trifle more south of east would be the direction of Bethlehem, which lies six miles south of Jerusalem. This last 25 miles of the journey would present a very steep climb of 2,600 feet to reach the top of the Judean plateau on which both cities rest. In modern times, this short trip takes two hours by train, with one locomotive in front and two in the rear.

If Venus was in its phase of greatest brilliancy in the early morning toward the end of the year 4 B.C., it would be in the constellation of Libra and 15 degrees south celestial latitude. As the Magi left the main highway at Lydda to turn toward Jerusalem, Venus, in all its glory, would shine above the Judean hills and appear directly above the city of Bethlehem. This would explain the position of the star, as described in that part of the chapter in St. Matthew which I have quoted above.

In the ninth verse of this same chapter, we read that after a conference with King Herod, ". . . they departed; and, lo, the star, which they saw in the east, went before them, till it came and stood over where the young child was." Now if the conference was in Jerusalem and they went south to Bethlehem, the star, if it were Venus, a little south of east, would not appear before them, but well to their left. The explanation of this lies in the fact that Herod had two palaces, an administrative one in Jerusalem, and a residential palace in the Samarian foothills, only a short distance from the Midian highway. The foundations of these two buildings still stand, the former being just inside the Jaffa gate and known to tourists as the Tower of David.

Herod probably summoned the Magi to his residential palace for the conference, and at its completion they again traversed the Midian highway as far as Lydda. This time there was no necessity for a visit to Jerusalem, so, guided by Venus, they climbed the Judean hills and were led directly to the city of Bethlehem.

"SUN-GAZERS ON TUTUJAN HILL"

(*Continued from page 5*)

eclipse, much less to photograph it. With the last spark of hope, I made all possible arrangements so that if the weather should clear we could try to photograph the eclipse, which we had previously ascertained from information supplied by The SKY's editor, was due to begin at about 2:00 p.m.

At about 1:45 the sky cleared in spots, and at 2:00 there were only low-flying fracto-cumulus clouds. Rejoicing mounted. A few friends called to join us in the observation of this unusual event. Several minutes after 2:00 p.m., just as I was being gently chided about the inaccuracy of my predicted time for the eclipse, we observed first contact. There was a rack of smoked glass slides, and many of these were soon put to use. Lt. Schwartz checked our photographic equipment, and I kept the 10½-inch mirror adjusted so that the solar image was maintained constantly in a fixed position in the focal plane. Lt. Schwartz placed a piece of white paper in the focal plane, which resulted in a very clear image, and amateur photographers began snapping cameras. We learned later that many of their photographs were excellent, showing a beautiful picture of the eclipse, although none showed the sunspots. A few snapped at the sun directly, or through smoked glass, but few of these pictures could have turned out with notably remarkable characteristics as the method gives a very small image: an image whose diameter is the focal length of the camera divided by 100.

During the entire eclipse it was my duty to act as coelostat, the only astronomical function possible for me under the circumstances, but a necessary one, as it was necessary to keep the sun's image in a fixed position, both for observation and for photography. Like most amateurs, my equipment and finances do not permit the luxury of a coelostat. So, by manually controlling the reflector, I compensated for the earth's rotation while photographers recorded the eclipse on film.

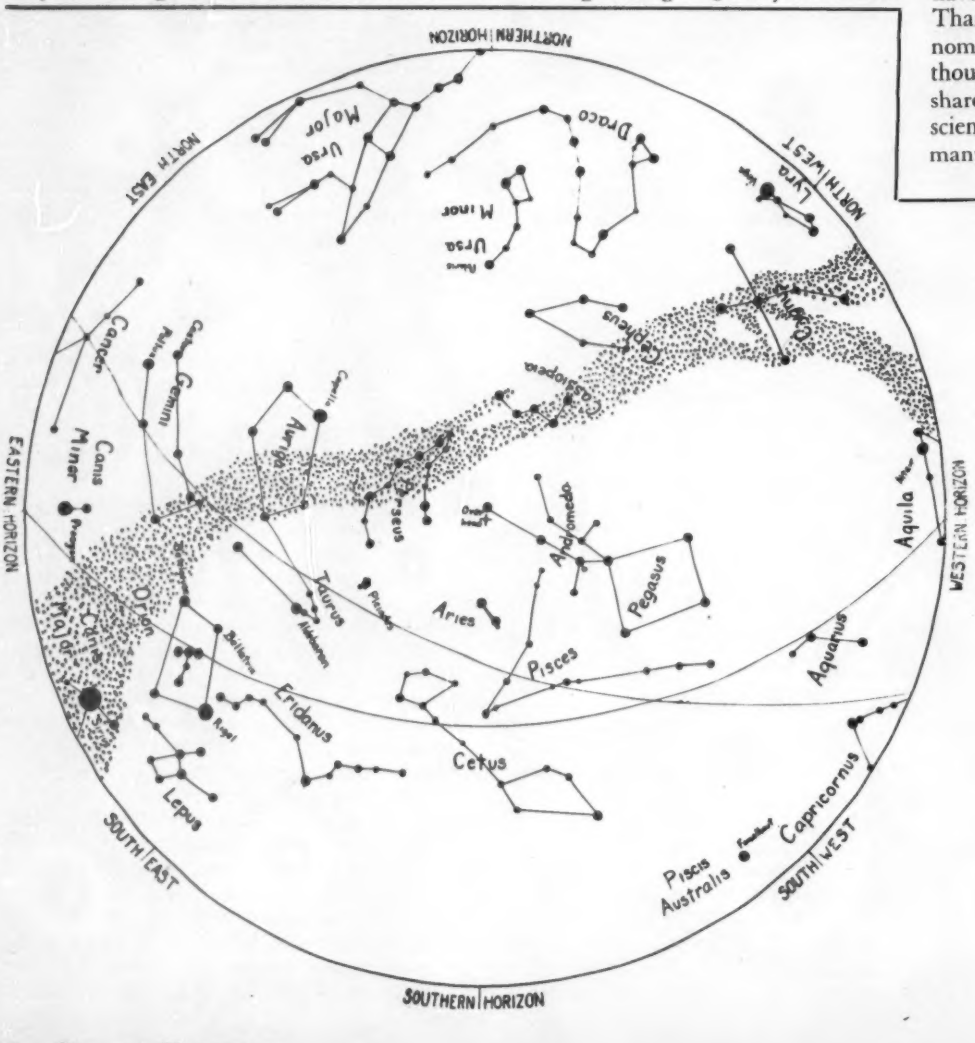
The eclipse was very nearly total in Guam. Birds were much disturbed, and pigeons gathered in large flocks to roost. Roosters crowed, and the air became noticeably cool. There were still drifting clouds, and they periodically obscured the sun, finally pouring forth a heavy shower as the eclipse reached the maximum stage. We sat in automobiles to escape the inclement elements, meanwhile observing the world growing steadily darker. After about five minutes of the downpour, we sighted a rift in the clouds through which we could see a strange cobalt-blue sky, with stars gleaming. Quickly the clouds drifted away, the rain stopped, and we beheld a most remarkable spectacle. Only the narrowest rim of the sun remained visible. The sky was of a dark, metallic hue, and all the clouds, even the fleecy ones, were dark for want of sufficient light to give proper color to their textures. Our photographic equipment remained ready, and we began work in a strange light, with odd shadows, and in an atmosphere of mingled joy over the sudden clearing of the weather, and of drinking in with our eyes this most unusual sight.

In only a few brief moments we saw that the maximum had passed. Meanwhile we continued to photograph. It grew steadily brighter, and after five minutes most of the unusual conditions had passed. Birds flew again, and the air became warm and bright.

We regret that we could do no better, but we felt we had accomplished one thing which could probably be considered unusual; we had obtained photographs showing a very active group of sunspots, as they appeared during an eclipse.

Mrs. J. T. Shultz, a local artist, made a linoleum cut of our eclipse party, showing the eclipse camera and a number of observers in humorous attitudes. This forms the front-page cover illustration for our monthly magazine of Guam news, a copy of which is enclosed.

But for your kind letter, we should have missed the observation of this eclipse. Thank you. It is hoped that our astronomical facilities here, amateur and limited though they may be, may have their share and their opportunity in this great science that is at the same time, to so many of us, a hobby.



THE STARS FOR DECEMBER

as seen from mid-northern latitudes at 9 p.m., December 7th; 8 p.m., December 23rd. Magnitudes of the stars are indicated by the sizes of the disks marking the stars, and the names of some of the brighter stars appear. The ecliptic and the equator are shown, the latter touching the horizon at the east and west points. See chart on the Observer's Page for the positions of the sun, moon, and planets as seen this month.

HERE AND THERE WITH AMATEURS

This is not intended as a complete list of societies, but rather to serve as a guide for persons near these centers, and to provide information for traveling amateurs who may wish to visit other groups.

City	*Organization*	*Date*	*Hour*	*Season*	*Meeting Place*	*Communicate with*
BOSTON	BOND AST. CLUB	1st Thu.	8:15 p.m.	Oct.-June	Harvard Observatory	Homer D. Ricker, Harvard Observatory
"	A.T.M.S OF BOSTON	2nd Thu.	8:15 p.m.	Sept.-June	Harvard Observatory	E. R. Lacy, Harvard Observatory
BROOKLYN, N. Y.	ASTR. DEPT., B'KLYN INST.	Round Table 3rd Thu.	8:00 p.m.	Oct.-April	Brooklyn Institute	William Henry, 154 Nassau St., N. Y. C., *BA.* 7-9473
BUFFALO	A.T.M.S & OBSERVERS	1st & 3rd Fri.	8:00 p.m.	Oct.-June	Museum of Science	J. J. Davis, Museum of Science
CHATTANOOGA	BARNARD A. S.	4th Fri.	7:30 p.m.	All year	Chattanooga Obs.	C. T. Jones, 1220 James Bldg., *CHat.* 6-8341
CHICAGO	BURNHAM A. S.	2nd & 4th Tue.	8:00 p.m.	Sept.-June	Congress Hotel	Wm. Callum, 1435 Winona Ave.
CLEVELAND	CLEVELAND A. S.	Fri.	8:00 p.m.	Sept.-June	Warner & Swasey Obs.	Mrs. Royce Parkin, The Cleveland Club
DAYTONA BEACH, FLA.	D. B. STARGAZERS	1st & 3rd Mon.	8:00 p.m.	Nov.-June	500 S. Ridgewood Ave.	Rolland E. Stevens, 500 S. Ridgewood
DETROIT	DETROIT A. S	2nd Sun.	3:00 p.m.	Sept.-June	Wayne U., Rm. 187	E. R. Phelps, Wayne University
"	NORTHWEST A. A. S.	1st & 3rd Tue.	8:00 p.m.	Sept.-June	Redford High Sch.	L. H. Sprinkle, R. 2, Farmington
FT. WORTH	TEX. OBSERVERS	No reg. meetings	.....			Oscar E. Monnig, 1010 Morningside Dr.
GADSDEN, ALA.	ALA. A. A.	1st Thu.	7:30 p.m.	All year	Ala. Power Auditorium	Brent L. Harrell, 1176 *W* or 55
INDIANAPOLIS	INDIANA A. A.	1st Sun.	2:00 p.m.	All year	Central Library Audit.	E. W. Johnson, 808 Peoples Bank Bldg.
LOS ANGELES	L. A. A. S.	2nd Thu.	8:15 p.m.	.....	2606 W. 8th St.	Charles Ross, 2606 W. 8th St.
LOUISVILLE, KY.	L'VILLE A. S.	3rd Tue.	8:00 p.m.	Sept.-May	Women's Bldg., Univ. of Louisville	Mary Eberhard, 3-102 Crescent Ct., *Taylor* 4157
MADISON, WIS.	MAD. A. S.	2nd Wed.	8:00 p.m.	All year	Washburn Observatory	C. M. Huffer, Univ. of Wisconsin
MILWAUKEE	MILW. A. S.	1st Thu.	8:00 p.m.	Oct.-May	U. of Wis., Ext. Div.	C. M. Prinslow, *Bl.* 4039
MOLINE, ILL.	POP. AST. CLUB	2nd Tue.	7:30 p.m.	All year	Sky Ridge Observatory	Carl H. Gamble, Route 1
NEW HAVEN	NEW HAVEN A. A. S.	1st Sat.	8:00 p.m.	Sept.-June	Yale Observatory	F. R. Burnham, 820 Townsend Ave., 4-2618
NEW YORK	A. A. A.	1st & 3rd Wed.	8:15 p.m.	Oct.-May	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., *EN.* 2-8500
" "	JUNIOR AST. CLUB	Alternate Sat.	8:00 p.m.	Oct.-May	Amer. Mus. Nat. Hist.	J. B. Rothschild, Hayden Plan., *EN.* 2-8500
NORWALK, CONN.	NORWALK AST. SOC.	Last Fri.	8:00 p.m.	Sept.-June	Private houses	Mrs. A. Hamilton, 4 Union Pk., 6-4297
OAKLAND, CAL.	EASTBAY A. A.	1st Sat.	8:00 p.m.	Sept.-June	Chabot Observatory	Miss H. E. Neall, 6557 Whitney St.
PHILADELPHIA	A.A. OF F.I.	3rd Fri.	8:00 p.m.	All year	The Franklin Institute	Edwin F. Bailey, *Rit.* 3050
"	RITTENHOUSE A. S.	2nd Fri.	8:00 p.m.	Oct.-May	The Franklin Institute	A. C. Schock, *Rit.* 3050
PITTSBURGH	A. A. A. OF P'BURGH	2nd Fri.	8:00 p.m.	Sept.-June	Buhl Planetarium	F. M. Garland, 1006 Davis Ave., N.S.
PORTLAND, ME.	A. S. OF MAINE	2nd Fri.	8:00 p.m.	All year	Private Homes	H. M. Harris, 27 Victory Ave., S. Portland
PROVIDENCE, R. I.	SKYSCRAPERS	1st Wed.	8:00 p.m.	All year	Wilson Hall, Brown U.	Ladd Obs., Brown U., *GA.* 1633
READING, PA.	READING-BERKS A. C.	2nd Thu.	8:00 p.m.	Sept.-June	Albright College	Mrs. F. P. Babb, 2708 Filbert Ave.
RENO, NEV.	A. S. OF NEV.	4th Wed.	.....	All year	Univ. of Nevada	G. B. Blair, University of Nevada
ROCHESTER, N. Y.	ROCH. AST. CLUB	Alt. Fri.	8:00 p.m.	Oct.-May	Eastman Bldg., Univ. of Rochester	P. W. Stevens, 1179 Lake Ave., *Glenwood* 5233-*R*
SAN ANTONIO	SAN ANT. A. A.	3rd Mon.	8:00 p.m.	All year	Le Villela	R. B. Poage, 807 Hammond Ave.
SCHENECTADY	S'TADY AST. CLUB	3rd Mon.	8:00 p.m.	All year	Observatory site	C. H. Chapman, 216 Glen Ave., Scotia
SOUTH BEND, IND.	ST. JOSEPH VAL. AST.	Last Tue.	8:00 p.m.	All year	928 Oak St.	Fannie Mae Chupp, 224 Seebirt Pl.
TACOMA, WASH.	TACOMA A. A.	1st Mon.	.....	All year	Coll. of Puget Sound	Geo. Croston, *Gar.* 4124
WASHINGTON, D. C.	NAT'L. CAP. A. A. A.	1st Sat.	8:00 p.m.	Oct.-June	U. S. Nat'l. Museum	Stephen Nagy, 104 C St., N.E., *Linc.* 9487-J
WICHITA, KANS.	WICHITA A. S.	2nd Tue.	8:00 p.m.	All year	East High Sch., Rm. 214	S. S. Whitehead, 2322 E. Douglas, 33148

Sky and Telescope is official publication of many of these societies.

★ ★

PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents in *December*, THE STAR OF BETHLEHEM. (See page 9.)

The Buhl Planetarium presents, beginning December 5th, "The Star of Bethlehem." What was the first Christmas star? Through many centuries men have wondered, and even today no one can be sure. But astronomers, among them the great Kepler, student of the planets and their motions, have named the astronomical possibilities. It is back to the world of ancient Palestine and the lands to the east that December visitors to the Buhl Planetarium travel, to relive the experiences of the shepherds who watched their flocks by night, of the Magi who journeyed to worship their new King. What did those men of so long ago, who held such primitive and simple beliefs concerning the universe, really see? Was it a star, or since "star" held so many meanings in those days, was it, perhaps, a comet, or a nova, or—most interesting possibility of all—a conjunction of bright planets in the sky? It is this ancient riddle that the modern magic of the planetarium helps to solve, as we recapture the feeling toward things celestial of 2,000 years ago.

★ **THE HAYDEN PLANETARIUM** presents in *December*, CHRISTMAS SHOW. (See page 9.)

In *January* and *February*, THE END OF THE WORLD. When and how will the end of the world come? Will the moon crash into the earth? Will the sun explode? Or will some other star race through our solar system, disrupting its orderly behavior? The drama of the world's final day is excitingly portrayed during January and February in the Hayden Planetarium.

★ SCHEDULE BUHL PLANETARIUM

Mondays through Fridays ..... 3, 8, and 9 p.m.
Saturdays ..... 2, 3, 8, and 9 p.m.
Sundays and Holidays ..... 3, 4, 8, and 9 p.m.

★ STAFF—*Director*, Arthur L. Draper; *Lecturers*, O. P. Keeney, Nicholas E. Wagman; *Business Manager*, Frank S. McGary; *Public Relations*, John J. Grove; *Curator of Exhibits*, Fitz-Hugh Marshall, Jr.

★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays ..... 2, 3:30, and 8:30 p.m.
Saturdays ..... 11 a.m., 2, 3, 4, 5, and 8:30 p.m.
Sundays—Mutual Network Broadcast—Coast-to-Coast .... 9:30-10:00 a.m.
Sundays and Holidays ..... 2, 3, 4, 5, and 8:30 p.m.

★ STAFF—*Honorary Curator*, Clyde Fisher; *Curator*, William H. Barton, Jr.; *Assistant Curators*, Marian Lockwood, Robert R. Coles.

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